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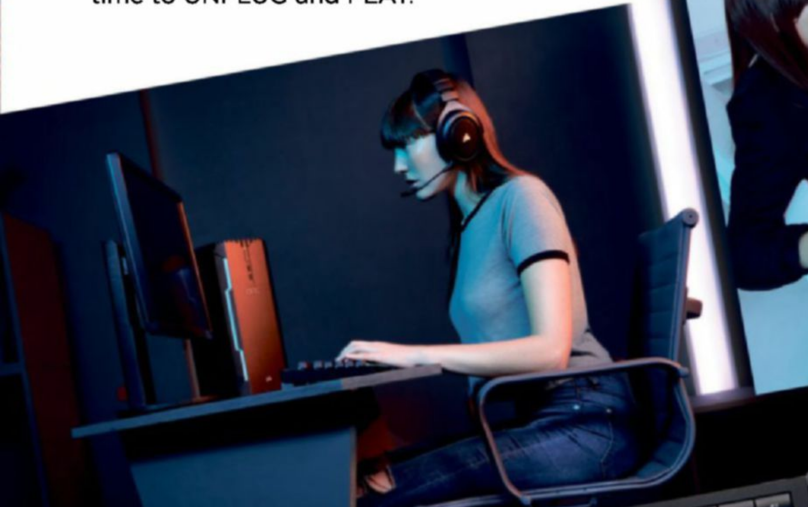

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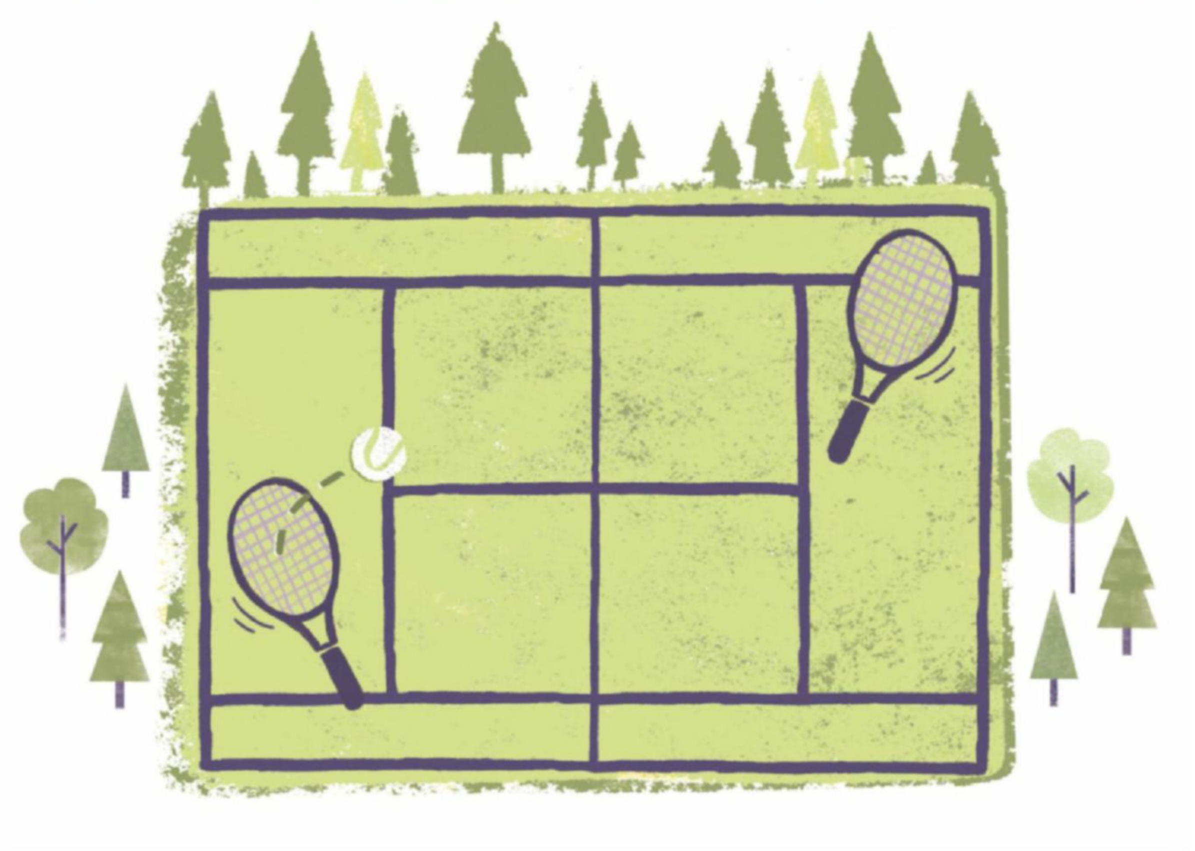

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ELECTRICITY IS THE NEW BLOOD

THIS YEAR, I attended my seventeenth CES. That's many trips to Las Vegas—every year since 2001—to gawk at the latest trends in technology. Each time, there's something new, and CES continues to evolve. When the show first started, it was mainly about computers, but these days it encompasses any kind of tech that touches people's lives. This includes cars, medical devices, home automation, TVs, cell phones, and, of course, computers—lots of computers.

But then something astonishing happened during the show: On day two of CES, the Las Vegas convention center lost power for nearly two hours. The show floor literally blacked out while I was traversing the endless aisles of booths. After a brief cheer by attendees, everyone then pondered what to do next. There wasn't anything anyone could do. There was no electricity.

Booths were powered down, endless devices were shut down, and computers were all turned off. It was a bizarre scene, to say the least, especially at the epicenter of all things connected. Suddenly, everything was disconnected.

It was wonderful. I mean, it felt great to see everything turned off, and all those devices and products no longer vying for your attention. There was a serenity to it that's difficult to explain. But then I could see the reactions of everyone else: What to do now? Most people just sat around on the show floor, some people left, and others laughed about the situation being funny, given that it's CES.

The blackout at the show demonstrated how deeply technology is integrated into our lives. Many jobs today use technology to make new technology. For those waiting for the cybernetics generation, it's already here. We don't actually have to wait for technology to be integrated into our bodies; it's already an extension of ourselves. Technology is more than just a tool—it embodies our personalities.

Take the PC as an example. We like to customize our PCs. We even want them to take on certain personalities through their appearances. Custom cabling, custom colors, custom RGB lighting—they are all extensions of our personalities. When we build our own PC, we're really augmenting part of ourselves. My PC does what I want it to do, although there are times when it's not behaving as I want. But even my own body doesn't always work well—I get sick, and sometimes I get cut and bleed, just like a leaky water pump.

We are electronic beings, with electronic body parts that we can leave at home or take with us. The benefit of these electronic extensions, though, is that they can all be upgraded and updated. I can't exactly do that with my limbs. The only thing is, electricity is the new blood. There's no way we'd survive without it. So I think what I'm trying to say is, I'm all for more tech. I'm welcoming our tech overlords.

Tuan Nguyen is Maximum PC*'s editor-in-chief, also known as "the pointy end of the stick." He's been writing, marketing, and raising hell in the tech industry for 20 years.*

↘ submit your questions to: comments@maximumpc.com

THE NEWS

The Meltdown and Spectre Legacy

The biggest bug in years will last for years, too

JUST AFTER the holidays, Google's security people, the Project Zero Group, along with a handful of other security research groups, let slip that they had found a potentially nasty security hole in just about every modern processor. News spread quickly, and such was the potential scale of the flaw that the mainstream press took up the story, and did the socially responsible thing of frightening everybody by telling them that their sensitive data was at risk.

The breaches quickly earned themselves names—Meltdown and Spectre—and logos. Both exploit loopholes in a chip's speculative execution procedure, a performance-boosting system where the processor makes an educated prediction about imminent procedures, and puts any unused cycles to work on them. To make this efficient, speculative execution functions can be granted a full backstage pass; they can get at otherwise protected memory.

Meltdown primarily affects Intel and some ARM chips, and can enable malicious code to break the isolation between application and OS, potentially leaving the kernel exposed. Spectre affects an even wider range of processors—just about every high-performance chip going. It works in a less direct way, but can also trick a system into handing over secrets. Because both exploit hardware bugs, they are difficult to patch and almost ubiquitous.

Security scares are nothing new. Generally, a security company will find a hole somewhere, quietly tell the OS boys, and when patches are ready, announce it to the world. The more potentially nasty the breach, the better the security company sounds, and the stronger the push toward patching and updating systems there is, so there is a tendency toward exaggeration. Pretty soon, nearly everybody has patched and fixed, and it transpires it wasn't really as bad as first reported, and life goes on as before.

These two troublemakers aren't your average buffer overrun flaws. Although first discovered last summer, the announcement still appeared to catch the industry by surprise. Microsoft and Intel both put out emergency patches, which proved flawed themselves. Microsoft issued six Win 10 patches in January alone. Some proved incompatible with third-party AV software, and others stopped some AMD machines from booting. The fixes also cause systems to slow down, from insignificant amounts to the point where Microsoft admits that "some users may notice a decrease in performance."

Intel's attempts at a patch were worse. It has advised that people don't now use its initial firmware patch, because it's unstable, and causes reboots in Haswell and Broadwell machines. Microsoft went as far as to issue a patch that disabled Intel's "fix." We currently await a stable firmware patch. There are signs that the industry did what it always advises us to avoid: panic.

Things are calmer now. You know the drill: Update your browser and OS if it hasn't been done automatically. Both vulnerabilities still require you to run malicious code on your system, and are read-only. There have been no attacks in the wild using either vulnerability yet. In fact, the only damage done so far has been from the buggy patches.

Meltdown and Spectre can fish out passwords and encrypted keys from your system, and since the root cause is buried deep in the hardware, they are going to be around for years to come, as ditching the culpable processors is hardly practical. We'll have to live with these two little menaces.

The long-term effect will be a performance hit, as speculative execution on the bugged processors can no longer be allowed free rein to work as it should. Everybody is going to lose a little here, and some I/O intensive tasks will take a double figure percentage drop, servers in particular. That's the real legacy here. Rats. The first round of patches should make things safe—let's hope that future patches can claw back some performance. **–CL**

> "There are signs that the industry did what it always advises us to avoid: panic.

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SECOND GENERATION RYZEN THIS SPRING

We have to wait another year for Zen 2, though

AMD'S RYZEN gave the processor market a jolt, it gave Intel something to think about, and accelerated roadmaps everywhere. And it has no plans to ease off just yet. This April, we should see the second generation Ryzen, the 2000-series or Zen+, code-named Pinnacle Ridge. The die shrink from a 14nm process to a 12nm node generally means faster clock speeds, and rumor has it we can expect around 200MHz across the board. AMD also reckons on a 10 percent performance bump from the shrink alone.

Internal changes include Precision Boost 2 and Extended Frequency Range. The headline is that boost will now kick in on all cores. Previously, if a game hit multiple cores, however lightly, it jinxed the boost. This stops that. The new chips will use the same AM4 socket, but we will also get a new X470 chipset better optimized for them. A BIOS update will be required for the older 300-series boards. Later in the year, we will also see Zen+ versions of Threadripper and Ryzen Pro, as well as more desktop APUs. On the graphics front, AMD plans to use its first 7nm Radeon Vega GPU specifically for machine learning and AI, an assault on Nvidia's lead. This will, as the industry puts it, "sample" later in the year.

Closer scrutiny of the roadmap shows that all this activity is filling in gaps in the lineup, and keeping existing designs competitive. The big change will come next year, when the Zen core moves to its second iteration. According to AMD, the Zen 2 design is complete. It will use GlobalFoundries' 7nm process, and build on the core of Zen, using ideas and features that were dropped from the original design due to time and budget restraints. Dropping to a die 58 percent the size will bring healthy rewards, too. AMD shows every intention of being fiercely competitive, which is good for all. **–CL**

NEW MOBO PLAYER IN TOWN

NZXT OPENS WITH STYLISH NEW BOARD

BEST KNOWN as a supplier of cases, power supplies, cooling kits, and such, NZXT has made the jump to motherboards, with the release of its N7 Z370. And a good-looking thing it is, too. The all-metal shroud comes in black or white, and gives it a cool, sleek look. The chipset and VRM heatsink covers can be had in blue, red, or purple for $15 more. The workings are based around a Z370 chipset and an LGA 1151 socket. It has an integrated RGB lighting controller, and is studded with headers to connect your own light show. It's not massively cheap, though; it started out at $299, but dropped to $249 after reviews praised its looks but thought it too expensive. It's an impressive first offering—we hope to see more of NZXT's uniquely stylish boards. **–CL**

CRYPTOCURRENCY HACK COSTS $534M

Partial refund is promised

COINCHECK, Japan's largest cryptocurrency exchange, has lost over half a billion dollars in the 8.5 hours it took to detect a security breach. The theft was of 523 million NEM coins—these were launched in 2015, and are currently the tenth largest cryptocurrency. Coincheck has promised to reimburse the 260,000 affected customers a total of $423m, about 90 percent of the loss. The exchange has received an order from the Japanese Financial Services Agency to review and strengthen its security. More official sanctions may follow. Thefts were all from hot wallets, Internet-connected ones. Coincheck stated that the huge majority of it assets were stored offline.

What is surprising is that this hack hasn't dented cryptocurrency markets, despite being the largest theft ever reported. The market remains stubbornly optimistic; 24 hours after the attack, Japanese cryptocurrency markets were as buoyant as ever. After a day of sober reflection, the bandwagon was back on a roll—almost every major coin, apart from NEM, registered decent gains. **–CL**

Tech Triumphs and Tragedies

A monthly snapshot of what's good and bad in tech

TRIUMPHS

✓ **NETFLIX REACHES 117.6M**
The streaming service is now worth over $100 billion, despite taking a $39m hit with Spacey.

✓ **8K SCREENS THIS YEAR**
The big TV manufacturers are all ready to launch 8K screens, though you may have to wait a while for content—years, in fact.

✓ **MUSK FLAMETHROWERS**
Elon Musk's Boring Company is advertising $500 flamethrowers for sale—he has $5 million in pre-orders so far.

TRAGEDIES

✗ **BALLISTIC MISSILE AHOY**
The Hawaiian Emergency Management Agency sent out worrying missile alert after a user pressed the wrong button.

✗ **AI REACHES PORN**
An AI system that puts faces on "actors" has had its servers shut down.

✗ **CHINA CUTS POWER**
The two largest crypto-mining companies have opened abroad as government restrictions on power consumption start to bite.

Jarred Walton

TECH TALK

Meltdown and Spectre Exploits Create Havoc

2017 MAY HAVE BEEN THE YEAR OF THE CPU, but 2018 has kicked off with some serious problems. Researchers have published details on two new exploits: Meltdown and Spectre. Reading through the whitepapers is like a crash course in CPU architectural design, as both exploits use some of the very enhancements that make modern processors so fast.

While Meltdown is perhaps the more serious of the two, Spectre may haunt CPU designers for years to come. Both use similar core ideas, with Meltdown attacking via the CPU's ability to do out-of-order execution (OOOE), while Spectre comes at things via speculative execution. Nearly all modern CPUs utilize these techniques to improve performance, which sometimes results in processors partially executing code that ends up being discarded. Things get cleaned up before the results of any code are finalized, and normally there's no cause for alarm. The problem is that Meltdown uses the code that partially executes to affect the cache hierarchy, so even though the final execution result is correct, the internal states of the CPU caches get altered.

Meltdown uses knowledge of Intel CPU architectures, combined with a "bad" instruction that shouldn't execute—but which does get partially executed—to figure out the contents of any part of system memory. I'm simplifying, but a memory access instruction is executed, with the results discarded later in the CPU pipeline. The prefetch logic of processors will still start to try to grab data from memory into the cache, however, and the exploit uses a Flush+Reload cache attack to figure out the secret value in the referenced memory. Meltdown has been demonstrated reading any memory in a system at around 500kB/s—not extremely fast, but fast enough if the memory contains usernames and passwords.

> “The bigger issue with Spectre is that variants could work on nearly any modern processor.

Don't let the cutesy icons fool you, Meltdown and Spectre are serious.

Spectre is more difficult to use, and requires code tailored for each microprocessor architecture. The whitepaper states that Spectre on a Haswell processor was able to execute up to 188 simple instructions that shouldn't normally run. The bigger issue with Spectre is that variants should be able to work on nearly any modern processor. Future chips will also likely be susceptible to this sort of attack.

The good news in all of this is that the researchers contacted the microprocessor companies, and work has been done to patch the system firmware as well as various operating systems to block the exploits. If that were the end of the story, it wouldn't be so bad, but those fixes come with compromises.

The biggest compromise is in performance. Depending on the workload, Intel has reported a performance drop of 0–25 percent, which means in some cases your processor just became as slow as a three-generations-earlier part. For most home users, the impact on performance is likely to be much lower, typically less than 5 percent. Gaming is included in this, so you're unlikely to see big drops in frame rates. Servers don't get off so easily, and cloud servers could be hit hard. That stands to reason, because before the patch, the Meltdown attack allowed one virtual machine (VM) to dump all the memory in use by any other VM—including passwords and other sensitive data, with no indication of a breach.

Perhaps most surprising is how far back the potential exploits reach. We're just hearing about them now, but Spectre attacks may be viable on hardware dating all the way back to the original Pentium Pro—over 20 years! Thankfully, Google's Project Zero helped find these holes so they can be plugged, but if your PC is more than five years old, you should probably start looking for an upgrade. But, then, you should have been doing that regardless.

Jarred Walton has been a PC and gaming enthusiast for over 30 years.

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Alex Campbell

OPEN SOURCE

Linux in a World of Web Apps

THERE ARE FEW THINGS more frustrating than realizing a key application has no Linux support. In a world where AppImage and Electron exist, vendors don't have excuses anymore.

The past few years have seen a big shift in the way computer applications are used. Long gone are the days when you had to go to a local computer store to buy a CD or stack of diskettes to be able to write up documents or do your taxes. Sure, you can still buy tax software in a store, but it's more likely that you'll download the software or use a web application.

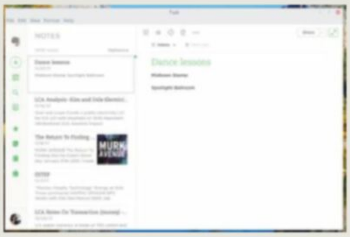
As more popular applications move to web interfaces, Electron has become a dominant method of displaying web views in a way that makes applications appear native, by using Chromium's rendering engine. Slack, for example, makes use of Electron to render its web application without the overhead of a full browser. The popular text editor Atom uses Electron as its base as well.

One might wonder why an Electron app is better than navigating to the app in a browser. Glad you asked. One of the main features is the ability to store data for offline use. Also, an Electron app has its own window, and won't get mixed up with the 40 other tabs you have open in Chrome or Firefox.

There are bad things about Electron, though. The main complaint is that instead of offering offline or desktop-specific capabilities, Electron apps can be half-assed wrappers for a web application. The other complaint is that some Electron apps can be quite heavy when it comes to memory use.

Even with the shortfalls, I still believe well-written and implemented Electron apps are a step forward for the Linux desktop. I feel some of you staring. Let me explain.

> Third-party developers stepped up to cobble together Electron wrappers for web apps. Why can't vendors do the same?



Tusk, an Electron-based AppImage app running on the GNOME desktop.

For as long as most Linux users can remember, major software vendors have steered clear of offering Linux versions of their applications. One of the main reasons for this is the fragmentation of the Linux desktop. First, a vendor has to develop a Linux version of the app, then target a specific GUI library (such as GTK or Qt), and package it for a specific distribution. All of that, of course, takes resources and time that may not be worth the effort. It was an easy cop-out that's also an easy way to have complaints from Linux users go away.

Fragmentation and development cost are big reasons Linux doesn't have official desktop versions of applications such as Evernote or OneNote. Solutions exist, but might be imperfect: Wavebox runs web apps in a single application, but costs $20 per year if you want to add more than two Google accounts.

With Electron and distribution-agnostic packaging formats such as AppImage, these arguments don't hold true anymore. With AppImage, the vendor has just one package format to consider, and they can be sure that the app will run on the overwhelming majority of reasonably modern Linux desktops. AppImages are user-friendly to people who are used to downloading an app for Windows or Mac OS. With an AppImage, all you do is download the file, set the permission of the file to executable, then double-click the file to run it.

With this technology available to app developers, there is little reason to avoid the Linux desktop anymore. Companies such as Evernote (I'll pick on that for now) have long resisted developing for Linux, citing development effort and fragmentation. Third-party developers stepped up to cobble together Electron wrappers for web applications. (Tusk is a good example of an Evernote Electron app available as an AppImage.) There is no reason vendors couldn't do the same—or, better yet, contribute code to those projects.

Both Electron and AppImage represent a path of least resistance to publishing apps on Linux. Going forward, saying "Linux users can use the web application" isn't acceptable anymore. Vendors, you can do better.

Alex Campbell is a Linux geek who enjoys learning about computer security.

THE LIST

THE COOLEST NEW TECH OF CES 2018

8

ACER SWIFT 7 Just 0.35 inches thick, this 2018 revision, with 8GB LPDDR3, a seventh-gen Core i7, and 4G LTE, is the thinnest ultrabook in the world.

7

HTC VIVE PRO 78 percent more pixels, a comfort-focused redesign, and a built-in headset—but it's HTC's upcoming wireless VR adapter that's most exciting.

World's First Rollable OLED TV
LG Display
LG Display

6

LG ROLLABLE SCREENS LG promised it, and it delivered: a 65-inch 4K panel that stows itself away in a roll. Super-cool, although some way off commercial release.

5

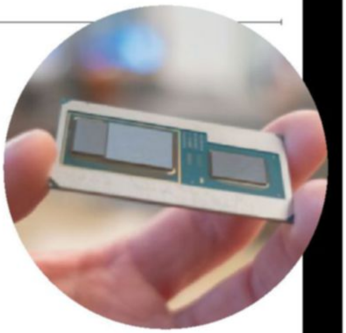
RAZER PROJECT LINDA The idea's nothing new (see Motorola's 2011 Atrix "Lapdock," for example) but Razer's phone dock concept could be great for Android gaming.

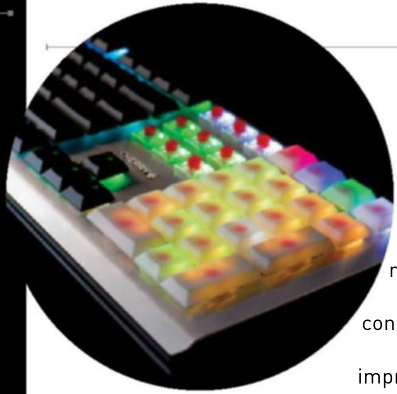
4

DELL 4K XPS 13 The finest little laptop around gets the boost to a 13-inch 4K panel, with the same negligible bezel and beefy battery of its forebears.

3

INTEL/ VEGA CPUS Eighth-gen Core processors with eight-lane PCIe 3.0-integrated Vega discrete graphics units. A rare collaboration that'll buff tomorrow's laptops hard.





2

CHERRY MX LOW PROFILE RGB 3mm travel mechanical switches for the space-conscious, with a clever lightpipe design for impressive illumination.

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NVIDIA BIG FORMAT GAMING DISPLAYS Ludicrous partner-built 65-inch 4K displays with G-Sync, 120Hz refresh rate, and built-in Nvidia Shield tech. You'll need a 1080 Ti and a fat wallet.

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HEAD TO

BY **ALEX COX**

Wired vs. Wireless vs. Charging Mats

We've come a long way from Xerox's three-button box with wheels on the bottom, but while there's a lot more to choose from, the importance of the mouse hasn't diminished. So, which to choose? We're smashing the three pillars of mousing against each other: the traditional, standard wired mouse; the pretty-much-standard wireless mouse; and the new kid on the block, the wireless charging mouse. Should you stay with what works, pick freedom over tethering, or empty your wallet in pursuit of a mouse that charges itself? Let's find out....

ROUND 1

Convenience

As with any attempt at making comparisons between competing standards, a great many of these categories will be highly subjective—and here's the first. A wired mouse is fundamentally less convenient than a wireless one, right? By virtue of the fact that you can't up and leave your desk with it, or pick it up and hurl it at a wall, without it pinging back on its own umbilical cord? Well, yes, and there are also less stupid reasons to appreciate wireless mice. Some are Bluetooth compatible, and can interact with your smartphone or tablet, as well as your PC. The lack of a cord means you'll never get tangled or snagged at the worst moment. Wireless mice are pretty awesome, both more and less so when a charging pad enters the fray. More, because you never run the risk of running out of battery power at the worst moment, and less because that expensive mat becomes an essential part of your mousing activities. But there's a reason that wired mice still exist: You can plug them in, and they enable you to point at things without any further fuss. That counts for something, at least.

Winner
Wireless

ROUND 2

Latency

The obvious, and actual, winner of the low-latency wars is the good ol' wired mouse. The speed at which signals can travel along a wire from your mouse to your PC, and subsequently be interpreted into movements, is fundamentally faster than any wireless solution. But not by much, in real terms. Contain your rage, but we're going to say it: Bluetooth's lag is only just perceptible. Most traditional RF wireless solutions manage a speed that, to the untrained eye, is completely instantaneous. And new technologies are arriving that drop the interpretation interval even further—Logitech's Lightspeed wireless communication, for example, purports to offer a 1ms latency. We've tested it, and we believe it; essentially, any reason you might have had to avoid wireless based on its sluggishness is dissipating quickly, even if you're a gamer with lightning reactions. Since we ought to mention it, wireless charging makes no difference to latency, or at least it shouldn't. Logitech's own charge pad, the Powerplay, includes a pass-through for a Lightspeed receiver, although not every charging solution will incorporate such tech.

Winner
Wired

ROUND 3

Reliability

Time for a bit of a tenuous argument? Why not. But let us begin with the truth: Wireless mice are the least reliable option. While interference is rarely an issue, and most broadcast systems can cope with a decent distance between mouse and receiver, the threat of disconnection is there. Worse: Sometimes batteries run out, and usually this happens at the absolute worst moment. If you're using a mouse with AA cells, you can switch them out quickly; with an internal lithium battery, you can generally plug in and switch to wired mode while charging. Both solutions are quick, but neither situation is ideal. Wired mice are far more reliable. Until something happens to the cable. Most wired devices are hard-wired, so unless you're adept with a soldering iron and a multimeter, a shredded cable means a new mouse. That infrequent, unlikely situation is why wireless charging wins this category for us. There's no risk of a flat battery, a natural encouragement to keep your mouse close to the receiver, and no cable to get eaten by your dog. A wirelessly charged mouse is always ready to go.

Winner
Wireless Charging

HEAD

Wired: What is a mouse without its tail?
Wireless: All mice deserve the freedom of wireless.
Wireless charging: Keep your mouse powered up without any effort.

ROUND 4

Cool Factor

Most wireless charging solutions are subtle enough that people won't ask you about them until you tell them about them. And, let's face it, you probably will. And they won't care. But your fancy, expensive mouse mat certainly means something to you: Charging your devices constantly and automatically is, while not flashy, damn cool. The freedom of wireless mice has its own intrinsic appeal, and a practical one, too, particularly because they enable you to move away from the desk, and get comfy elsewhere. Design-wise, wireless mice don't tend to differ too much from their wired cousins, at least in terms of shape, but in the world of PC peripherals, "cool factor" generally has to mean "covered head to toe in RGB LEDs." Wired, therefore, takes this category hands down; wireless devices, desperate to maximize battery life, tend to shun pretty lights, although charged mice are likely to get brighter as time goes on. With a wire, there are heaps of gaudy, customizable options, tons more mice with extra buttons and gimmicks, and just much more choice. That sounds pretty cool to us.

Winner
Wired

ROUND 5

Value

Wireless charging, at least right now, is exorbitantly expensive. Far too expensive, if we're being honest, but as the tech matures and its adoption increases, we expect the price will drop down. Whether it will ever dip low enough to win a price comparison contest, though, is highly unlikely, particularly given the affordability of standard wireless and wired mice. Value is another subjective subject—does the usability and flexibility of wireless make its dollar price irrelevant? Should we be looking at the bottom end of the market, where you can pick up a convincing-looking (but probably absolute garbage) 2.4GHz wireless mouse for $3 and change, or a functional wired mouse for a buck? No. That's not what we're about. Looking at quality peripherals highlights a slight premium in the price of wireless mice, particularly where they have wired counterparts sporting much the same tech. You won't have to replace batteries often—depending on your usage and the particular mouse, it could be anywhere from three months to a year—but that's an additional running cost that wired, our winner, just doesn't have.

Winner
Wired

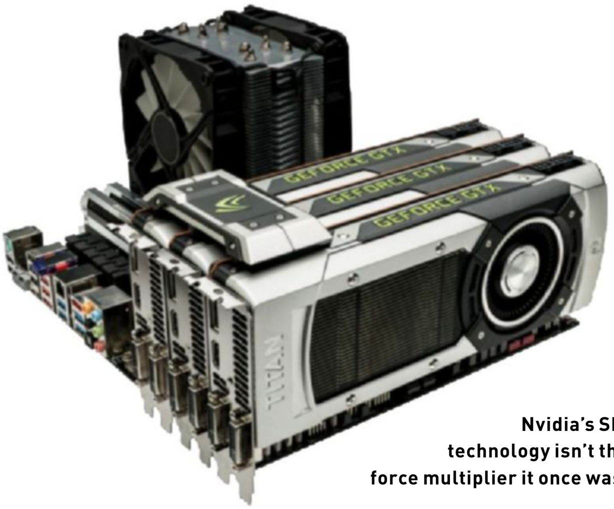
And the Winner Is...

Wired mice are the best mice. This result is not simply a case of us being curmudgeonly or pushing some agenda—your mouse, even more than your keyboard, is the most critical input device you have connected to your PC. Precision, speed, accuracy, and reliability are paramount. Going wireless means making sacrifices, no matter how small, and the minuscule chance of your cord getting tangled or chewed doesn't outweigh the possibility of your battery dropping out at just the wrong moment, or that critical mouse twitch coming in a half second too late. Wireless mice are much better than they used to be, and picking one up is absolutely not a bad choice, but this is "Head to Head," it's a fight, and we have to determine a winner. Wireless charging is an odd fish, because you don't need it, it's too pricey, and there's little practical benefit beyond removing the possibility of your mouse losing juice—but, damn, it's nice to have. We're still fine with wired mice, but a wireless pad (if we're not paying) is a solid second choice.

DOCTOR

THIS MONTH THE DOCTOR TACKLES...

> Reviving an Old PC
> Win 10 Licenses
> GPU Quandaries



Nvidia's SLI technology isn't the force multiplier it once was.

Back From the Dead?

Hi, Doc. I'm a huge fan of your column; it's probably my favorite part of *Maximum PC*.

My dad recently got a new job, and I went to help him clean out his old office. He told me that anything I found in the boxes was mine to take, including an unopened HP xw4200 Workstation with a 3.4GHz Pentium 4 CPU, an ATI FireGL V3100 graphics card, and 1GB of DDR2 RAM (not to mention five 160GB HDDs).

Anyway, my 32-bit Windows 10 Pro installation disc got annoyed at this thing, so the PC is now happily crunching away beneath my desk with a 32-bit build of Ubuntu 15.10 instead. The only real problem at this point is that Linux doesn't like any of my Wi-Fi dongles, and my desk isn't near any Ethernet ports. As a result, I can't do anything useful because I don't have an Internet connection.

I have to admit that I'm hopelessly lost trying to install drivers for my Wi-Fi dongles on this beast, and I'm not particularly comfortable with Ubuntu's lack of fancy settings that I grew accustomed to in Windows 10. So, I wanted to ask if you know of a low-resource Windows 8 or 10 option compatible with my hardware? More importantly, do you know how I can connect this behemoth to the Internet?

It's not a big deal if I have to ship this thing off to a thrift store. After all, my other two computers are just fine and dandy. But I feel that giving it a good home and a productive job is the least I can do to make up for the 12 long years it spent languishing unloved in a cardboard box. **–Kieran Al**

THE DOCTOR RESPONDS: Windows 10's minimum hardware requirements are the same as Windows 8.1, which were the same as Windows 7. You need a 1GHz CPU, at least 1GB of RAM (for the 32-bit version), 16GB of available hard drive space (again, for the 32-bit version), and a DirectX 9-compatible graphics card. On paper, your workstation should be compatible. Try downloading Microsoft's Media Creation Tool and building a bootable flash drive. If the process fails again, there may be an incompatibility that the Doc doesn't currently have enough information about to troubleshoot.

As far as Internet connectivity goes, you have a couple of different options. First, you can find a way to make the on-board Broadcom 5751 GbE controller work, at least until you can get the operating system updated. Windows 10 might not like the newest driver, so visit HP's support site for an older one. Version 14.2.0.5 reportedly does the trick. Or, invest in a more modern USB-attached Wi-Fi dongle. They aren't terribly expensive, after all.

Moving a Win 10 Key

I have to perform a clean installation of Windows 10, which was a free upgrade from Windows 7 Professional. I created a bootable DVD of the installation files after I upgraded my PC.

If I use this DVD to reinstall Windows 10—which, by the way, is specific only to my home-built PC—is the free Windows key recognized and accepted, giving me back my activated copy of Windows?

For your information, my computer is running fine except for one problem. My webcam microphone (a LifeCam Cinema) level drops to zero in Skype, and the person on the other end can't hear me, even though I can see and hear just fine. I've used every resource available, including Skype's community and all of the suggestions found on Google. However, I cannot get the issue fixed. **–Mike M**

THE DOCTOR RESPONDS: If you upgrade a retail copy of Windows 7, 8, or 8.1 to

↘ submit your questions to: doctor@maximumpc.com

Windows 10, that license can be transferred to one other PC, so absolutely, it remains valid on the same system after formatting and starting anew. An upgraded OEM license cannot be transferred to another PC. However, there should be nothing stopping you from formatting and reinstalling Windows. And, of course, if you own a retail copy of Windows 10, it can be transferred without limit, so long as the license is only active on one PC at a time.

Rather than booting from a DVD, though, give Windows 10's "Reset this PC" option a try. Open the Windows menu, select "Settings," click "Update & Security," then pick the "Recovery" option. When you choose to "Get started" under "Reset this PC," you're given the option of keeping your files or removing everything (and starting over). This way, you shouldn't have to worry about knowing the product key—reactivation is automatic.

Patching the Holes

Hey Doc, I hope that you can help me. I've been told that there is an update for Intel's Management Engine, and it is very important. I have all of the latest updates installed, including the BIOS. I even snagged the MEUpdateTool utility for my Asus Prime Z270-A motherboard with a Core i7-7700K.

So, how do I install it? Do I need to go to the BIOS or open a command prompt? If you could give me detailed instructions on how to protect my system, I'd appreciate it.

–Ken Payne

THE DOCTOR RESPONDS: For anyone who missed it, Intel acknowledged vulnerabilities in its Management Engine, Server Platform Services, and Trusted Execution Engine, identified by third-party researchers, late last year. The company published a detection tool that tells you if you're affected.

Asus's MEUpdateTool utility can be extracted to your desktop and run directly. Note that Asus also recommends updating your Management Engine driver to v.11.7.0.1045. While you're at it, there's a new firmware build (1203) available for the Prime Z270-A.

SLI vs. One GPU

Hello, Doctor. I am in the process of acquiring parts for a new rig. At more than five years old, my existing machine is aging fast. I'm currently planning to wait until summer to buy the GPUs, since today's prices are so brutal. But I recently heard something that has me in need of advice.

I have my motherboard (an ASRock X370 Taichi), my CPU (a Ryzen 5 1600X), my case, tubing and blocks for liquid cooling, and a 64GB memory kit. Clearly, I want this rig to last a while. The original idea was to buy a pair of GeForce GTX 1080s and use them in SLI. Then somebody told me that SLI is unstable in some games, and may actually cause performance losses. This makes no sense to me, though, as everyone still seems to be building SLI-equipped systems. The person who warned me off SLI, however, wouldn't respond when I asked for some sort of proof that the technology can be problematic.

I'm no noob to building, but I haven't paid much attention lately to the issues plaguing particular parts. Is this a GeForce GTX 1080 thing, or an isolated incident where someone's expectations weren't met? Is the performance gain available from SLI enough to warrant buying two 1080s over a single 1080 Ti? I'll be doing a lot of gaming and would like to hit 3840x2160 at decent frame rates. As mentioned, prices are way up, but I'm hoping they drop eventually (then again, 1080 Tis were cheaper than 1080s the last time I checked). I just want to know what I'm getting myself into.

–Kurt Colbourne

THE DOCTOR RESPONDS: Unfortunately, Kurt, there's a lot going on right now to complicate your question.

For one, modern low-level graphics APIs give games explicit control over GPUs. This means that developers have to deliberately expose multi-GPU support, rather than allowing drivers from AMD or Nvidia to handle the task transparently (as they did under DirectX 11). In theory, that opens the door to higher frame rates, thanks to more efficient resource utilization. But launch schedules often force developers to pick and choose where they spend their time. Given the minority of gamers with multiple graphics cards installed, it's hardly surprising that explicit multi-GPU often gets cut.

We've seen this functionality added post-launch through patch updates. And we've also seen other AAA titles eschew multi-GPU support under DirectX 12 altogether. It's no surprise, then, that neither CrossFire nor SLI have the ubiquity they did back when AMD and Nvidia controlled their optimizations.

Of course, you're always welcome to flip over to DirectX 11, where multi-GPU profiles still work the way they did pre-DX12. It's just that, given the direction traditional and virtual reality games are going, the Doc typically recommends buying the fastest single GPU you can afford, and sidestepping compatibility issues altogether. One GeForce GTX 1080 Ti already serves up playable performance.

Helping Each Other

Doc, love your column! I have the exact same camera as Nick, who wrote in a couple of months back with problems getting smooth playback after copying files from his Sony FDR-AX53. I, too, had a hard time getting content to my 4K TV from the AX53.

The solution for me was a Minix Neo U1 Android box. I put files from the camera on a Netgear ReadyNAS hooked up via Gigabit Ethernet, and networked the Minix Neo U1 similarly. I didn't use wireless at all.

4K playback just needs a cheap streaming media hub.

I use a stock installation of Kodi on the Neo U1, just to play those Sony 4K files. The combination works great, giving me an easy way to watch 4K files on a 4K TV. I simply browse the NAS and click a thumbnail. The output looks great. The only bad thing is that those files eat up a ton of hard drive space.

Feel free to pass along my comment, and keep up the great work!

–Bill

THE DOCTOR RESPONDS: Thanks for the tip, Bill!

A Photoshop PC

Hi Doc, I enjoy reading about your latest builds. My current computer was pieced together in the Windows XP days, so it's time for a couple of new systems: I want one for gaming and another for Photoshop. I have 20,000-plus digital images dating back to the very first digital cameras. This means I have a lot of storage space. But is there a specific configuration or graphics card that you would suggest for the task?

–Robin Fry

THE DOCTOR RESPONDS: In general, Photoshop responds well to CPUs with high clock rates (lots of cores aren't necessary), at least 16GB of RAM, and solid-state storage. A modern, mid-range desktop graphics card is ample if you find yourself using GPU-accelerated filters.

Incidentally, those recommendations also work well for gaming PCs, so you may only need to build one system after all.

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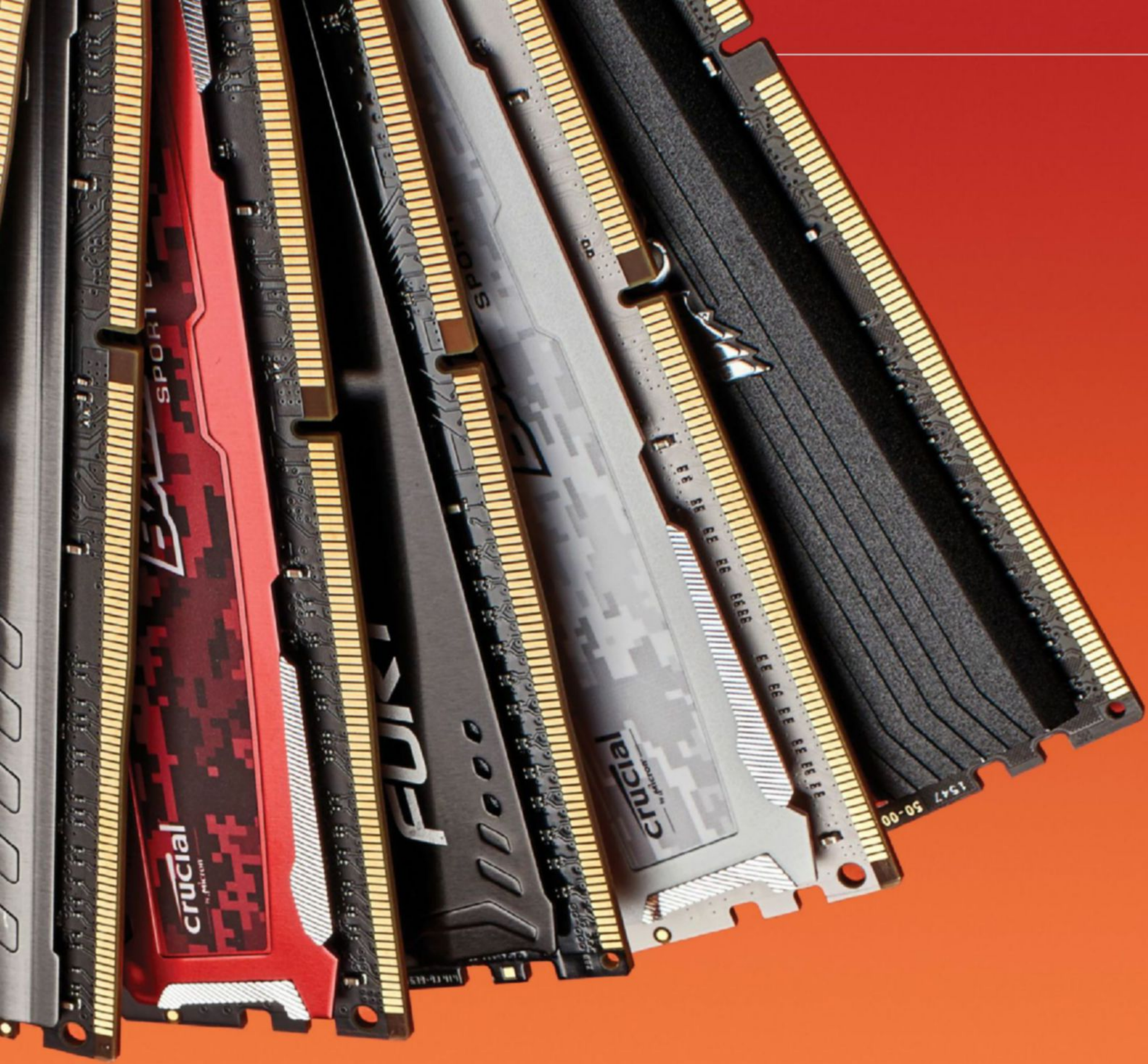
MEMORY MATTERS



A fresh look at the state of DDR4 in 2018

WE OFTEN DESCRIBE the PC as having its own ecosystem, almost as though it's some form of living entity, and the symbiotic relationship between each component is almost a perfect example of Aristotle's (oft misparaphrased) saying: "The whole is more than the sum of its parts." Admittedly, the Greek philosophical genius was likely referring to metaphysics and ideologies, rather than the modern-day abacus, yet in our eyes the saying is more apt here than anywhere else.

After all, you only have to take one core component out of the typical system's arsenal, and you render the machine incapable of function. Whether that's processor, motherboard, or memory, the crux of the matter is that this holy trinity of hardware combines to create a perfect amalgamation of machine-based interfacing—yet, isolated, the components themselves hold far less value.

Not only does this metaphor suit the PC itself, but it also extends to the PC marketplace. With the prices of both memory and GPUs skyrocketing, inevitably those generational spikes in performance we've been seeing across the computing industry over the last 10 years are going to evaporate—because the price of memory has nearly tripled, new platform adopters are forced to go for lower-spec parts.

This has a knock-on effect across game development, video production, CGI.... Hell, even us tech journos are going to feel the bite. Whether it's mining, supply issues, or a bit of both, the ecosystem is suffering, and there's not a lot we can do to change that, but understanding how memory works, and what you should be spending your cash on, as far as memory is concerned, is now more pivotal than ever. So, it's time for us to bust out the magnifying glass, and shine a light on the volatile world of memory.

The Obsession With Speed

MEMORY SPEED is one of the most convoluted specifications around, and is often misrepresented. Way back when, in the early days of SDRAM development, the megahertz measurement was the correct way of advertising the associated speeds of memory. In short, every single solid-state component in your machine operates at a specific frequency, or Hz—whether it's your processor, GPU, memory, or even SSD, each one operates on a cycle. Like the ticking of a clock, each tick represents a single hertz or cycle (the opening and closing of a transistor gate, in this case). A speed of 1Hz, for example, is one cycle per second; 2Hz is two per second; a MHz is 1,000,000 cycles per second; you get the picture.

The problem is, when DDR (or double data rate) RAM came on the scene, it changed how data transfers were registered. Instead of only actuating once on the rising of each clock cycle, it could now also process an additional operation on the fall of that same clock cycle, effectively doubling the rate at which the DIMM could process data. The figure for accurate measurement of data transfer requests then shifted from MHz to MT/s to adjust for this change, despite the fact that memory still operated at the same frequency. However, marketing apparently didn't get that memo, because many companies, in a bid to tout it as the next big thing, ignored the MT/s figure, instead referring to it as MHz, while modern-day memory quoted at 2,400MHz, for instance, only operates at half that frequency.

crucial
BALLISTIX
SPORT DDR4

Timings and Latency

THE NEXT part of the holy trinity of memory specifications revolves around timings and latency. There's a ton of them, but the most important one you need to keep in mind is the CAS latency. Referring to the Column Address Strobe, this figure indicates just how many clock cycles it's going to take for the memory module to access a particular memory location, either to store or retrieve a bit of data held there, ready for processing by the CPU.

That said, this figure on its own doesn't give you all the information you need. It's only when you combine it with the memory transfer rate we mentioned above that you get a better picture of just how fast your memory modules are. So, how do we get a figure that makes any sort of logical sense to us consumers? Well, there's a handy formula that converts CAS latency and MT/s into a real-world latency: Latency = (2,000/Y) x Z, where Y is your RAM's speed in MT/s, and Z is your CAS latency.

So, as an example, if we take a 2,666MT/s memory kit, operating with a CAS latency of 15, we get a real-world result of 11.25ns. This tells us exactly the total time it takes for that memory module to access, store, or request a bit of data from a location on the module.

This is where overclocking memory typically comes unstuck. Generally, the higher the frequency, the higher the CAS latency, and as such, real-world performance gains are often slim, unless the rise of that CAS latency is slowed as well. When it comes to the "best" performing memory, what you're looking for is a kit that has a high frequency, a low CAS latency, and the necessary capacity (see opposite) to do what you want to do.

RAM LATENCIES

Technology	Memory Chip Capacity	Transfer Rate (MT/s)	CAS Latency (ns)	Real Latency (ns)
DDR2	500MB	400	5	25.00
DDR2	500MB	800	5	12.50
DDR3	1GB	800	9	22.50
DDR3	1GB	2,400	11	9.17
DDR4	2GB	2,133	15	14.06
DDR4	2GB	4,500	19	8.44
DDR5*	4GB	4,266	23	10.78
DDR5*	4GB	6,400	27	8.44

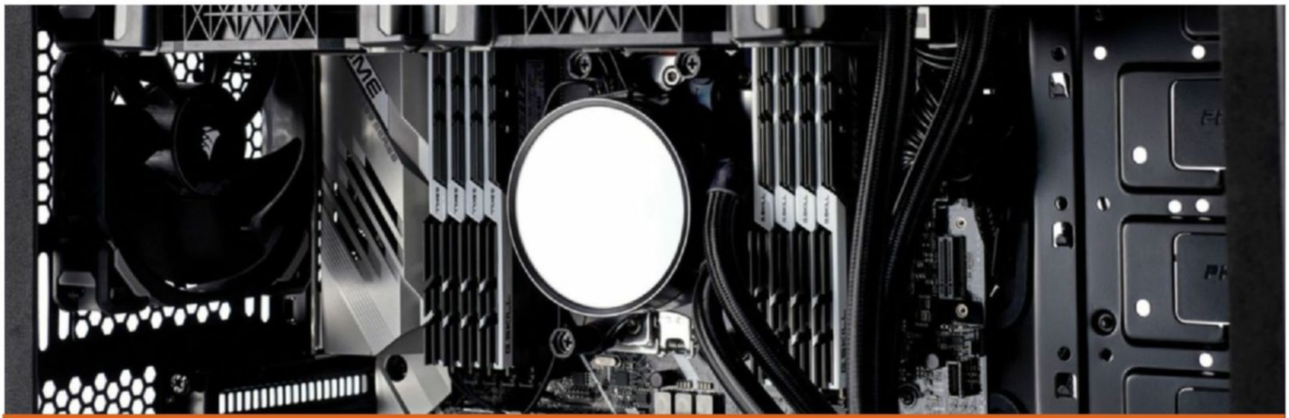
*Hypothetical figures based on speculative guesses from industry insiders.

Capacity for Capacity

TO UNDERSTAND how memory capacity is calculated, we have to look at how the chips themselves are designed. This starts with JEDEC, an association of over 300 different companies that focus on solid-state technology. Its task is to ensure that universal standards are used across the registered companies when it comes to solid-state tech, with a particular emphasis on DRAM, solid-state drives, and interfaces (NVMe and AHCI, for instance). What this does is ensure that the consumer won't have to pick between four different connection standards for DDR4, for example, and everything is consistent across multiple manufacturers—aka no proprietary BS. As far as memory is concerned, JEDEC lists the criteria that, say, DDR4 needs to adhere to—for instance, the number of pin outs, the dimensions of the chips, the maximum power draw, and more.

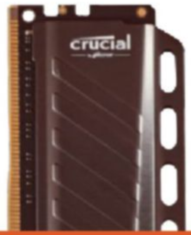
That spec is then handed over to the manufacturers, such as Samsung, SK-Hynix, Toshiba, and Micron, to produce memory chips to their own specifications that fit into JEDEC's criteria. Typically, the differences lie within the size of the manufacturing process used (which additionally affects power draw). These chips are then bought by aftermarket partners, such as Corsair, HyperX, G.Skill, and so on, to be assembled with their own PCBs, heatsinks, and aftermarket features (RGB LEDs, anyone?), while, of course, still adhering to JEDEC's original outline.

Currently, due to limitations in transistor size, DDR4 chips are limited to just 1GB each, although a theoretical 2GB per chip is well within the JEDEC specification. In the consumer market, most DIMMs can only support up to a maximum of 16 memory chips per stick, meaning a maximum capacity of 16GB per DIMM is possible. You can find larger sticks in the enterprise market, typically featuring up to 32GB per stick, but these are designed for server use rather than the consumer market, and are priced into the thousands.



HOW MUCH MEMORY?

So, in this world of hyperinflated memory prices, just how much DDR4 is enough for what you want to do? It's tricky. A year or so ago, we would have happily sat here and recommended 64GB of DDR4 for any video editor or content creator out there. But, to be honest, given the ludicrous price increases (more on that later), that's just not a practical or good use of your money in this day and age.



4GB

If all you're building is a home theater PC or a machine for low-end office work (we're not talking 4,000-cell Excel files here), then arguably a single 4GB stick of low-spec DDR4 should be perfect for the job. Couple that with a low-end Pentium part, and you're all set. For those keen miners out there, this is also the ideal spec for a cryptocurrency mining rig, because mining is typically not as memory-intensive as other more mainstream applications (but you should pass on the Pentium if you're planning to mine CPU-intensive currencies).

8GB

If entry-level gaming is your jam, 8GB (2x 4GB) is the absolute minimum we'd recommend at this point in time. Ironically, the lower the amount of VRAM on your GPU, the more likely the system is to cache overly large texture files on to the actual RAM itself (here's looking at you *CoD: WWII*)—dual-channel here helps with those massive transfers.

16GB

For mid-range to high-end gaming, you absolutely need that 16GB of DDR4. Annoyingly, more and more games are starting to use more and more memory. Yearly releases and poorly optimized titles are putting more strain on system memory, with even *Star Citizen* recently announcing a minimum spec of 16GB of RAM purely to run the Alpha. 16GB is also a nice middleweight RAM capacity for any task you want to throw at your rig. Whether that's extensive office work, Photoshop, entry-level videography, you name it, it's the right spec for you.

32GB

For anyone who makes a living from 3D modeling and content creation, 32GB is the way to go for the time being. Although this will more than likely still set you back $400 or more, it's the absolutely perfect amount for applications such as After Effects, 4K Premiere Pro, and more.

32GB-plus

For now, unless you can somehow get it aggressively subsidized, anything beyond 32GB just isn't worth it, at least not until prices drop below that $500 mark once more.

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Price Hikes

IF YOU HAVEN'T built or upgraded a machine recently, you might not realize that memory pricing has gone crazy over the last 12–16 months. Memory kits have seen their prices at least double during this period, with some almost trebling. That means that while, a year or two ago, the amount of memory you put in a system could be decided on a whim, it now has to be a carefully thought-out plan if you want to keep any machine up to date and capable of the workloads intended. But why have prices increased so much? And what are the chances of them coming back down to more reasonable levels?

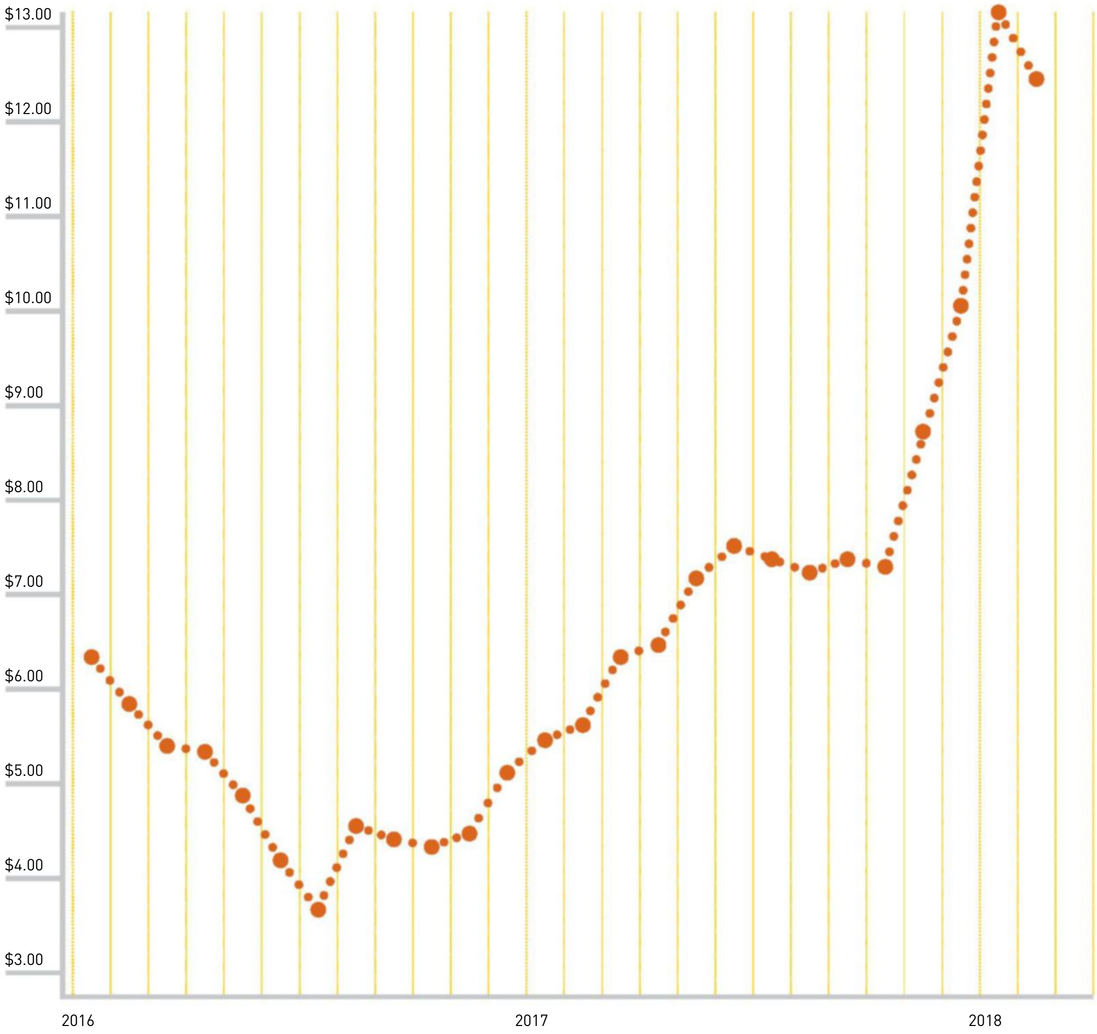
The biggest problem for DRAM is that producing flash is far more lucrative. The reason for this is primarily down to one thing: smartphones. The specifications for these tiny powerhouses are constantly on the rise, so the amount of storage and RAM they ship with has risen sharply recently. As they are premium products, the amount of money being charged for them has gone through the roof.

You might be sitting there thinking that high-speed desktop DDR4 RAM has nothing to do with NAND flash, and in a sense you'd be right, but the plants that manufacturer NAND are also the ones responsible for our beloved DDR4. So, because it's financially more advantageous to switch over to NAND, that's exactly what has happened, and will probably keep happening for a while yet. It might be important to us, but desktop RAM is relatively low on the pecking order as far as manufacturers are concerned. There is another reason for the current high prices, though, and that's down to market demand. We had some decent platform releases last year, which meant there has been a slew of people in the market looking to buy more RAM. Yes, it's Ryzen's fault. Well, not really, but the new platform has certainly not helped the situation.

If you're looking to upgrade a system with more RAM, it could be worth hanging tight for a little longer, because the memory market has a history of righting itself once serious money is involved. If you're looking to build a new system, your options aren't as obvious, because the simple fact of the matter is that RAM is going to cost you. Buy wisely. And be ready to pounce when pricing does return to more reasonable levels.

MEMORY PRICING GONE HAYWIRE

We've collated the **average memory prices** over the last two years from the three builds that grace the rear of the magazine. This is an average of memory pricing across all three rigs, on a per gigabyte basis (which helps mitigate the fact that the turbo build tends to use 4x 8GB DIMMs, while the budget build uses a pair of 4GB sticks). How we pick memory for these builds is also affected by pricing—if RAM prices are high, we pick lower-frequency DIMMs. So, there is some margin of error, but the general trend shown in this graph is hard to ignore.



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Channel Bandwidth

WHAT IS channel bandwidth and how does it affect memory? Think of it as the maximum amount of data that can be transferred at any one time between your system and the memory installed. It's calculated by using MT/s, the width of the memory bus, and the number of memory channels your system supports. So, for a typical Ryzen 7 1800X system, featuring 16GB (2x 8GB) of 3,200MT/s DDR4, it's something like this.

3,200,000,000 (3,200MT/s) x 64 (64-bit bus) x 2 (dual-channel) = 409.6 billion bits per second, or 51,200MB/s ,or 51.2GB/s.

That's the absolute maximum amount of data the system could transfer between the memory and the processor at any given time, before bottlenecking. If you were to use a 4x 4GB kit on your dual-channel board, bandwidth wouldn't increase, because the processor can still only read and write from two memory channels at a time (thus the dual-channel spec), despite the fact that you have four DIMMs installed. On the flip side, installing just one DIMM cuts that figure in half.

It's worth noting that for most applications, dual-channel memory kits provide you with more than enough bandwidth for everything you want to do on your desktop. However, for applications that manipulate massive data sets, textures, and more, an increase in channel support can eliminate potential bottlenecks, because more powerful processors become more capable at manipulating larger data sets. 4K, 5K, and 8K video editing in After Effects, for instance, benefits greatly from having access to both a larger memory capacity and increased memory bandwidth, thanks to quad-channel support.

THE FUTURE

JEDEC is poised to announce the next-gen memory standard (DDR5) later this year, and has confirmed a few details for us: "DDR5 will offer improved performance, with greater power efficiency compared to previous generation DRAM technologies. As planned, DDR5 will provide double the bandwidth, and density over DDR4, along with delivering improved channel efficiency."

That's exciting, if only for the fact that power consumption should drop—DDR3 sat at 1.5V and DDR4 at 1.2V, so it's likely we'll see DDR5 at 1.0V or lower. The doubling of density means we'll likely see mobos double in max capacity, too, with mainstream platforms maxing out at 128GB, and high-end desktops hitting a 256GB limit. Expect initial MT/s figures to hit around 4,133MT/s, with latencies at 27ns if not more. However, it's unlikely to come into production until late 2019.

Standardization

WHAT EXACTLY are JEDEC's standards? And why are they necessary? Well, the biggest reason they exist is to ensure consumers have a non-convoluted platform. They also ensure that motherboard manufacturers don't have to design four different types of motherboard, just because Corsair has its own connection standard, HyperX another, and G.Skill a slightly different variant. You get the picture. Think of it like USB, but for memory. The biggy is that all 300 members can pool their resources to accelerate technological development, without any one of them getting a competitive edge, and saving them time and money in the process.

It's worth noting that JEDEC's standards are on the fairly conservative side of things when it comes to memory frequency (after all, they're designed to work with everything from desktops to servers and supercomputers), and DDR5 has yet to be clarified in its entirety just yet, but you can see from the table below just what standards each manufacturer has to adhere to.

JEDEC STANDARD DDR4 MODULE

Standard Name	Data Rate (MT/s)	Module Name	CAS Latency (ns)	Real Latency (ns)
DDR4-1600J	1,600	PC4-1600	10	12.50
DDR4-1600K	1,600	PC4-1600	11	13.75
DDR4-1600L	1,600	PC4-1600	12	15.00
DDR4-1866L	1,866	PC4-1866	12	12.86
DDR4-1866M	1,866	PC4-1866	13	13.93
DDR4-1866N	1,866	PC4-1866	14	15.01
DDR4-2133N	2,133	PC4-2133	14	13.13
DDR4-2133P	2,133	PC4-2133	15	14.06
DDR4-2133R	2,133	PC4-2133	16	15.00
DDR4-2400P	2,400	PC4-2400	15	12.50
DDR4-2400R	2,400	PC4-2400	16	13.33
DDR4-2400U	2, 400	PC4-2400	18	15.00

Intel How memory speeds affect Big Blue

WHEN IT COMES TO MEMORY, over the years Intel's architecture has benefitted very little from increased frequencies. Certainly, the current mainstream platform sees little to no performance increases when fixed up with higher frequency memory with lower latencies. When it comes to mainstream applications, gaming, and even video editing to some degree, if you're sitting pretty on Z77 and above, you'll likely have enough bandwidth to do anything you want, without having to shell out for higher frequency kits for the additional bandwidth. There is one area where Intel does benefit from higher frequency memory, though, and that's file compression. If you're exporting and sending compressed files on a day-to-day basis, memory speed does help significantly. That said, it's a fairly niche scenario. All we can suggest, then, is that the best thing to do when speccing out a new system is to find a reasonable frequency (2,400 or 2,666MT/s) memory kit at a capacity that suits your needs. We've recommended a few kits as examples (see opposite), so pick a kit with similar specs for as little money as you can find.

BENCHMARKS

8GB DDR4	Cinebench R15 Single/Multi (Index)	AIDA 64 Memory Read (MB/s)	AIDA 64 Latency (ns)	Total War Warhammer II (Low and Avg fps)	Middle Earth Shadow of War (Low and Avg fps)	10GB WINRar Archive Time (Seconds)
Core i7-8700K @ 2,400MT/s	204/1,521	35,933	65	38/43	22/51	245
Core i7-8700K @ 2,666MT/s	205/1,522	39,418	53.1	39/43	28/53	232
Core i7-8700K @ 3,000MT/s	205/1,527	44,130	51.2	39/43	25/53	223
Core i7-8700K @ 3,200MT/s	204/1,526	46,802	47.3	31/43	34/51	215

BENCHMARKS

16GB DDR4	Cinebench R15 Single/Multi (Index)	AIDA 64 Memory Read (MB/s)	AIDA 64 Latency (ns)	Total War Warhammer II (Low and Avg fps)	Middle Earth Shadow of War (Low and Avg fps)	10GB WINRar Archive Time (Seconds)
Core i7-8700K @ 2,400MT/s	204/1,515	35,282	57.5	38/43	34/51	245
Core i7-8700K @ 2,666MT/s	205/1,532	38,936	53.4	33/43	24/51	231
Core i7-8700K @ 3,000MT/s	205/1,544	43,662	49.3	33/43	35/52	225
Core i7-8700K @ 3,200MT/s	204/1,541	46,153	47.1	38/43	24/52	216

BENCHMARKS

32GB DDR4	Cinebench R15 Single/Multi (Index)	AIDA 64 Memory Read (MB/s)	AIDA 64 Latency (ns)	Total War Warhammer II (Low and Avg fps)	Middle Earth Shadow of War (Low and Avg fps)	10GB WINRar Archive Time (Seconds)
Core i9-7900X @ 2,400MT/s	195/2,175	62,432	84.4	33/43	29/52	197
Core i9-7900X @ 2,666MT/s	194/2,167	70,065	77.3	36/42	32/51	192
Core i9-7900X @ 3,000MT/s	191/2,197	77,599	73.8	31/43	24/51	185
Core i9-7900X @ 3,200MT/s	194/2,177	83,063	70.3	34/43	26/52	182

Our test bed consists of an Asus Z370 Maximus X Hero for the Core i7, and an Asus X299 Prime Deluxe motherboard for the Core i9.
All memory tests were performed with either 8GB or 16GB Corsair Dominator Platinum DIMMs, with a CAS latency of 16.

Maximum PC Recommended Specs

RIGHT THEN, what do we recommend, memory-wise, for your latest immersion into the Intel platform? Well, given the vast swathe of different setups and use cases out there, we've categorized our selections into three rather generic specs: one for office work, one for gaming, and one for creating grade-A quality content. It's worth noting that you don't have to stick with the brands we've highlighted—because prices are fluctuating about rather haphazardly at this point, you'll probably find brands jumping in and out of being the best value kit you can get. Stick with trusted brands, such as Corsair, Crucial, G.Skill, and HyperX, though, and you'll be good.

OFFICE & HOME THEATER

As we mentioned earlier, if all you're wanting to do is run office software and browse the web, a single stick of DDR4 4GB will do you just fine. Unfortunately, that means you'll be forking out about 50 whole smackeroonies for this 2,400MT/s kit (sadly, that's the state of affairs we're now faced with). Real-world latency is pretty attractive, though, coming in at 12.5ns at CAS 15—not that it'll matter for these kind of applications.

DDR4
FURY
HYPERX

HyperX Fury 4GB (1x 4GB) @ 2,400MT/s, CAS 15 **$45–$55**

GAMING

16GB is ideal for future-proofing yourself against the inevitable rise of HD texture packs and unoptimized AAA titles. Yes, devs should be working harder on coding, rather than the "can it run *Crysis?*" crapfest of a mindset, but there's not a lot we can do to influence that. 2,400MT/s at 16GB is perfect under Intel's platform. Combine that with a CAS latency of 16, for around $170, and you've got a fast (13.34ns) future-proof kit.

BALLISTIX
SPORT DDR4

Crucial Ballistix Sport LT 16GB (2x 8GB) @ 2,400MT/s, CAS 16 **$160–$180**

WORKSTATION

Until memory prices change, 32GB is the go-to spec we recommend for anyone looking at the more expensive workstation-oriented stuff. There's some good value kits out there—Corsair's Vengeance LPX series, in particular, has long been a staple of our high-end test benches. Again, as Intel doesn't benefit much from the frequency side of things, 2,666MT/s is a sweet deal for any would-be video editor.

VENGEANCE
LPX
DDR4

Corsair Vengeance LPX 32GB (4x 8GB) @ 2,666MT/s, CAS 16 **$350–$400**

AMD Memory mastery for Team Red

RYZEN IS AN oddity when it comes to memory. For the first time in eons, memory speed impacts processor performance. Simply going from 2,666MT/s to 3,200MT/s can equate to a performance increase of around 10 percent in rendering tasks. Combine that with an overclock on your Ryzen CPU, and you can net yourself almost 25 percent more grunt. Why is this? It's all down to how AMD has crafted its Infinity Fabric. This is the interface that connects all the core complexes in the processor together, enabling them to communicate with one another. The Infinity Fabric is directly controlled by the IMC (integrated memory controller), so the higher the speed of the memory, the faster the IMC operates, and the quicker the processor can transfer bits of data across each core complex. It's a smart solution, but it does mean that Ryzen is somewhat bound by its dependency on faster memory—not so good when the memory market is priced as high as it is today. So, best bet? If you're heading toward Team Red's Ryzen platform, get the highest frequency memory you can, at a capacity that best suits you.

BENCHMARKS

8GB DDR4	Cinebench R15 Single/Multi (Index)	AIDA 64 Memory Read (MB/s)	AIDA 64 Latency (ns)	Total War Warhammer II (Low and Avg fps)	Middle Earth Shadow of War (Low and Avg fps)	10GB WINRar Archive Time (Seconds)
Ryzen 7 1800X @ 2,400MT/s	156/1,607	37,299	91.4	32/42	18/51	344
Ryzen 7 1800X @ 2,666MT/s	153/1,615	41,307	87.3	33/42	22/50	340
Ryzen 7 1800X @ 3,000MT/s	154/1,632	46,202	79.9	37/43	28/51	316
Ryzen 7 1800X @ 3,200MT/s	155/1,638	48,473	76.5	35/43	31/51	308

BENCHMARKS

16GB DDR4	Cinebench R15 Single/Multi (Index)	AIDA 64 Memory Read (MB/s)	AIDA 64 Latency (ns)	Total War Warhammer II (Low and Avg fps)	Middle Earth Shadow of War (Low and Avg fps)	10GB WINRar Archive Time (Seconds)
Ryzen 7 1800X @ 2,400MT/s	153/1,607	36,523	93.7	30/41	17/51	345
Ryzen 7 1800X @ 2,666MT/s	149/1,612	40,436	88.9	30/41	18/50	336
Ryzen 7 1800X @ 3,000MT/s	150/1,620	45,717	80.6	37/43	29/52	319
Ryzen 7 1800X @ 3,200MT/s	154/1,632	47,850	75.1	35/43	27/52	311

BENCHMARKS

32GB DDR4	Cinebench R15 Single/Multi (Index)	AIDA 64 Memory Read (MB/s)	AIDA 64 Latency (ns)	Total War Warhammer II (Low and Avg fps)	Middle Earth Shadow of War (Low and Avg fps)	10GB WINRar Archive Time (Seconds)
Threadripper 1950X @ 2,400MT/s	141/2,891	56,524	113.7	38/43	24/55	532
Threadripper 1950X @ 2,666MT/s	138/2,902	62,712	106.2	31/43	25/54	505
Threadripper 1950X @ 3,000MT/s	140/2,939	71,961	97.0	39/43	24/53	472
Threadripper 1950X @ 3,200MT/s	139/2,945	74,992	94.3	39/44	23/53	464

Our test bed consists of an Asus X370 Crosshair VI Hero for Ryzen, and an Asus X399 ROG Zenith Extreme motherboard for Threadripper.
All memory tests were performed with either 8GB or 16GB Corsair Dominator Platinum DIMMs, with a CAS latency of 16.

Maximum PC Recommended Specs

NOW WE'VE WRAPPED up exactly how AMD benefits from memory speed in particular (thanks, Infinity Fabric), it's time we got down to the nitty-gritty of recommending some kits and specs. As with the Intel recommendations, it's worth noting that you don't need to stick with the brands we've picked out below, because prices are fluctuating about rather haphazardly at this point. We've just tried to balance, price, spec, and performance to come up with the perfect pairings for your AMD-based build.

OFFICE & HOME THEATER

Let's assume you have an old GPU from an out-of-date system that you're going to be plugging into this build, because until the Zen APUs come out, you'll need a dedicated GPU to run a Ryzen HTPC or office system. A single stick of 4GB DDR4 at 2,666MT/s fits the bill perfectly. Ryzen has always been a bit fussy with memory, so make sure you go for a mainstream brand here, and stick with 2,666MT/s and above where you can.

DDR4
FURY
HYPERX

HyperX Fury 4GB (1x 4GB) @ 2,666MT/s, CAS 16 **$50–$60**

GAMING

That price jump is painful, but we reckon it's worth it for this kit. For gaming, frame rates matter, and near-instantaneous communication between Ryzen's intricate core complexes certainly helps batter those low frame rates into submission, at the very least. With a super-low latency of 10ns, a 3,200MT/s kit with a CAS latency of 16 will set you back a good $200, but it's definitely the best way to game on Ryzen. Period.

VENGEANCE LED

Corsair Vengeance LED 16GB (2x 8GB) @ 3,200MT/s, CAS 16 **$180–$210**

WORKSTATION

We've opted for more capacity here, but a slight drop in frequency in contrast with the gaming recommendation above. This is mostly centered around the notion that the gains from Threadripper's memory speed increase (from 3,000 to 3,200) weren't that impressive. That said, it's still a kick-ass kit, and the latency combo is perfect, if you can get a kit at a good price. G.Skill's Ripjaws V series is the best value we've seen so far.

VENGEANCE
LPX
DDR4

Corsair Vengeance LPX 32GB (4x 8GB) @ 3,000MT/s, CAS 15 **$370–$420**

THE BEST **FREE** PC SOFTWARE

Tool up your PC for less with 39 essential gratis apps

By Alex Cox

Free software drives the PC industry. Paid-for packages might seem to be the better option in general (and if you're in industry, you'll need the professional support options that come from paying up), but it's the no-bucks-down applications that make life as an everyday PC user worth living.

We have three things to thank for the delicious software cornucopia that we've spread on the table today. First, the dedication and skill of the open-source community, predominantly those propping up the Linux world. These guys see a problem, they find something they want to do, and just go ahead and make it, offering up the software—and the building blocks that put it together—to the world when they're done. Thanks, folks. You rock, and you make the next generation of software better.

Second, we must thank the power of competition. Take web browsers: Had one tech big boy not stuck his finger in the Internet pie, chances are the rest of them wouldn't have followed suit in a bid to do things better, and taste that sweet, sweet market share and goodwill. Their generosity might be tinged with a combination of industrial malice and "you are the product" data collection, but sometimes you pay for your software in something other than hard cash.

Thirdly, and perhaps a little ironically, good old capitalism has a big role to play in the existence of the best free software. Some apps are made as alternatives to software that people resent having to pay for. Some are a free sample, a tantalizing just-useful-enough morsel to encourage you to invest in the whole meal. Whatever the reason, you get something awesome, and you don't have to pay a cent.

So, let's go ahead and make your life better by making your PC more capable. Let's get you set up to try new things, to create more, to break down format boundaries, to enjoy yourself. Let's go free: We've trawled the web, canvassed our colleagues, and batted away a host of competitors to compile this guide to the absolute best free software for Windows and, in many cases, Linux, too.

MEDIA

1

PHOTO EDITING
GIMP

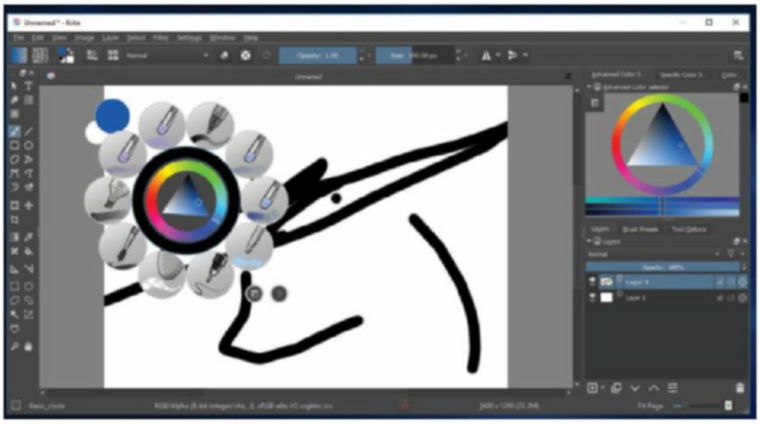
About as Photoshop as you can get without actually shelling out a small fortune to use Photoshop itself, Gimp is densely packed with features, and capable of a massive array of photo manipulation and artistic endeavors. It's also far more refined than it was a few years ago, with the frequent crashes of yesteryear all but gone. Only the slightly janky interface remains to remind you that this is open-source software. (See page 66 for a project that uses Gimp.)
www.gimp.org

2

NATURAL PAINTING
KRITA

Now 20 years old, Krita is a natural painting toolbox, perfect for everyone from artists to cartoonists, and beyond. It includes art essentials such as stabilized brushes, a pop-up palette, a wrapping texture mode, as well as a full animation interface. There are nine individual brush engines, each customizable and organizable to help you grab the right tool fast. Pick up the paid-for Gemini version on Steam ($9.99) if you're rocking a convertible tablet and want to support the project.
http://krita.org

Allow your inner artist to express themself with veteran painting app Krita.



VLC Media Player can handle pretty much any media format you care to throw at it.

3

VIDEO EDITOR
LIGHTWORKS

If you're after pro-level video editing, Lightworks—legitimately used to cut proper Hollywood movies, such as *The Wolf of Wall Street*—is an incredible choice for the grand sum of zero bucks. You're restricted to 720p output on the free tier, but everything else is present and correct, from advanced non-linear editing to a whole host of color grading and effects tools. The learning curve is steep, but there's a vibrant community ready to help if you need any pointers.
www.lwks.com

4

MUSIC PLAYER
MUSICBEE

No matter how large your music library is, MusicBee can handle it, with a tiny RAM footprint that makes this handsome skinnable player/manager perfect for even the lowliest laptop. You can tweak your sounds with surround upscaling, ASIO and WASAPI support, and a 15-band equalizer, and even make use of those crusty old WinAmp plugins if you need more. It'll even properly tag and fully organize that trashpile you call an MP3 collection....
http://getmusicbee.com

5

YOUTUBE DOWNLOADER
FREEMAKE VIDEO DOWNLOADER

Downloading from YouTube isn't strictly kosher, but nothing's permanent on the Internet's foremost demonetization platform. It pays to be prepared if there's a video you can't do without—particularly if your data plan won't cover streaming your kids' favorite weird Spiderman/Elsa escapades when you're desperate for them to be quiet for two seconds. Freemake's multithreaded app is super-simple, super-fast, and it can suck down YouTube vids as well as content from Vimeo, Facebook, and beyond.
www.freemake.com

6

AUDIO EDITOR
AUDACITY

Active development means that this audio stalwart has recently seen a bunch of new features added, and there are more on the way. Not that it necessarily needed much

changing: Despite a rather, let's say, rugged interface, Audacity's power for multitrack audio manipulation is unsurpassed in the free bracket, and it's an immensely stable way to record from a microphone, too. Of course, now that it can natively play MIDI files, you'll be too busy looping canyon.mid to get any fresh recording done.
www.audacityteam.org

7

VIDEO PLAYER

VLC MEDIA PLAYER

VLC is brilliantly honest free software. When its creators were offered tens of millions of dollars to slather the app in ads, they refused—it's open source, proud about it, and the envy of the media player world, thanks to its solid compatibility with just about every media format. It can even handle streams on several protocols, and it's fully extendable. That said, everything important is on board from the start—no codec packs required.
www.videolan.org

8

STREAMING AUDIO

SPOTIFY

Despite the fact that it's cavorting around an increasingly competitive streaming playground, Spotify is still king of the jungle gym. It has the biggest library, the best interface, and its OGG-format files sound all but flawless, despite its lack of official high-res audio support. Admittedly, the ads can be a little repetitive and heavy handed if you don't shell out for a paid-for account, but that's the price of free.
www.spotify.com

9

VECTOR IMAGE EDITOR

INKSCAPE

You don't have a huge amount of choice if you need to create scalable vector graphics on a budget. You could shell out for a subscription to use Adobe Illustrator, or you could download the highly mature and feature-filled Inkscape. There's not really a happy in-between. Good job, then, that Inkscape is so capable, with support for blurring, gradients, multi-path editing, and exporting in every format you could possibly need.
http://inkscape.org

10

VIDEO MANIPULATION

HANDBRAKE

When you need video in one format but it's stubbornly in another, you need to transcode. Handbrake supports a massive list of formats on input and output, with profiles included for a host of common devices, and it's happy to convert frame rates and add effects on the way. Its key feature, though, is batch processing: Drop a collection of videos in, set it off, and it'll tell you when it's filled a folder with your freshly converted media.
http://handbrake.fr

GAMING

11

VALVE STEAM

Frequent sales, a massive indie library, and an early access program that gets you into new games before they've been officially released characterize Valve's store—but it's the little extras, such as the vibrant community, the Steam game overlay, and the Steam Workshop for mod content, that really make it. Steam has changed what gaming really is on the PC. Keep an eye on the store to find regular free weekends of popular games, which get you unlimited access for a limited time.
http://steampowered.com

12

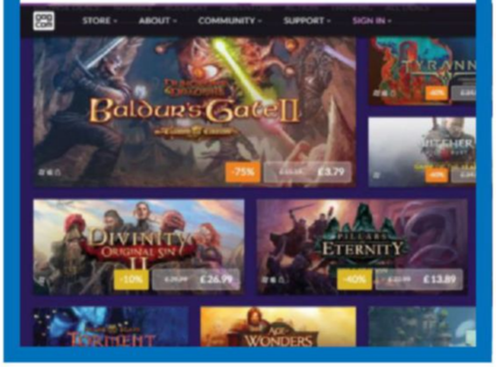
EA ORIGIN

Steam's publisher deals don't extend to every producer of AAA titles, and if you want in on EA's library, you need to use Origin. Whatever you might think about the gaming monolith's practices, Origin is a convenient way to manage your gaming, and get going with multiplayer action. Check the "On the House" section for a regular rotating selection of freebies, which you can add to your library forever, and take advantage of the trials to get time-limited access to hot new games.
www.origin.com

13

GOG GALAXY

If you're more inclined toward the old-school end of the gaming spectrum, GOG's selection of rigged-for-modern PC classics and the occasional new release are reasonably priced and almost always worth checking out. Galaxy is its desktop client, which makes finding and installing your favorite DRM-free titles quick and easy; if you're on board with GOG's philosophy and truely love old games, you should get on board with Galaxy.
www.gog.com/galaxy



SECURITY & PROTECTION

14

SOFTWARE REMOVAL
PC DECRAPIFIER

Whether you're cleansing a new PC of its preinstalled bloatware or trimming down an existing machine to get rid of the stuff you really don't need, PC Decrapifier does the job fast, and it makes it easy. No other package is quite as informed on the awful software that manufacturers so thoughtfully include, and how safe it is to excise it—while you won't use it often, this is definitely one of those portable apps you'll want on your USB toolkit stick.
www.pcdecrapifier.com

15

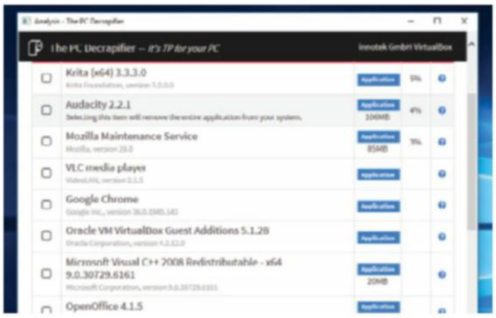
SYSTEM CLEANING
CCLEANER

Windows is, among its many other jobs, like a cut-price janitor. Sure, it puts on a good show: It's packed with tools, and it claims they'll scrub your OS clean, but it's lackadaisical. It doesn't go as far as it could, and it often leaves filth around the edges. For the rest, you need something heavy, such as CCleaner, which can do away with Registry artefacts, files left over after uninstalling, and much more.
www.piriform.com

16

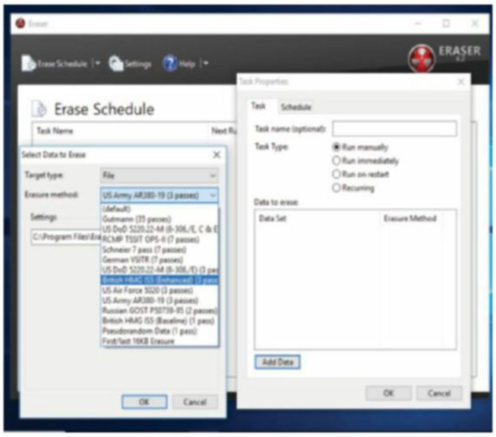
VPN
TUNNELBEAR

There are stacks of free VPNs out there, but never underestimate the importance of trust when it comes to something that's purportedly there to protect your web traffic—you need to know you're safe, not just funneling your entire bitstream through a criminal server. Cuddly ol' TunnelBear can be trusted, and it's completely uncomplicated: It just works. It's fast, it's solid, and the 500MB monthly free bandwidth should see you through all your secure transactions.
www.tunnelbear.com


Analysis - The PC Decrapifier
The PC Decrapifier — it's TP for your PC
Innotek GmbH VirtualBox
Application

☐ Krita (x64) 3.3.3.0
☐ Audacity 2.2.1 — Selecting this item will remove the entire application from your system. — 106MB
☐ Mozilla Maintenance Service — 85MB
☐ VLC media player
☐ Google Chrome
☐ Oracle VM VirtualBox Guest Additions 5.1.28
☐ Microsoft Visual C++ 2008 Redistributable - x64 9.0.30729.6161 — 20MB
☐ OpenOffice 4.1.5

PC Decrapifier jettisons the junk from your system—essential for new PCs.



Target type: File
Erasure method: US Army AR380-19 (3 passes)
Settings: C:\Program Files\Era

Task name (optional):
Task Type: ● Run manually ○ Run immediately ○ Run on restart ○ Recurring

Want to make sure those files you deleted are gone for good? It's time to turn to Eraser.

17

ANTIVIRUS
BITDEFENDER ANTIVIRUS FREE

Whichever way you slice it, however careful you may be, you can't get away without having antivirus installed. If you're going free, pick something with low system load, minimal amounts of notification spam, and a decent engine behind it. Bitdefender's latest update fits the bill—it's ultra-effective against malware, and extra light on resources, with a simple interface that just gets on with the job. Try Avira instead if you'd like a touch more control.
www.bitdefender.com

18

ANTI-MALWARE
MALWAREBYTES FREE

Admittedly, Malwarebytes' free tier doesn't do a huge amount—it's not a preventative, it won't steer you away from the seedier corners of the web, and it can't do anything about zero-day malware threats, unless you pony up some cash. What it does, though, is precisely what you need it to: Run it once you think you've fallen foul of some terrible malware threat, and it'll kill that pesky infestation until it's well and truly dead.
www.malwarebytes.com

19

PASSWORD MANAGER
DASHLANE

If you've never used the same password for multiple sites because you don't trust your memory, you're in the minority, and if you came up with that password yourself, chances are it's insecure in some way. Using Dashlane does away with the fallibility of the human

brain. Remember one master password, and you need never even know the complex, nigh-unhackable passwords it automatically generates and types into web forms on your behalf—even Dashlane itself doesn't know them.
www.dashlane.com

20

FILE DESTRUCTION

ERASER

You're probably already aware that deleting a file doesn't actually delete it. It's not until its little corner of drive space is reused that its data actually goes away, and even then there may be some trace of it left behind to be forensically recovered. Eraser ensures that those files you want well and truly removed are fully destroyed, using specially selected patterns of bytes over multiple passes to remove any digital memory of those files ever existing.
http://eraser.heidi.ie

21

SYSTEM PROTECTION

UNCHECKY

Probably the most common cause of malware infestation is inattention—clicking through a seemingly innocent installer, accidentally skipping past the page where it offers to install a brilliant browser toolbar, cursing yourself afterward. Unchecky doubles up: It unchecks those cheeky checkboxes (as you might expect from its name), and also sniffs out untrustworthy installers, warning you when you're about to accept an offer of questionable value.
http://unchecky.com

22

FILE RECOVERY

RECUVA

It doesn't matter if you've accidentally deleted a file, formatted a drive, or suffered some sort of horrific crash, Recuva can take a good stab at analyzing your drive, and getting your data back in one piece. It's not infallible, but if you have the time (and your hard drive has enough life left in it) to let it run a deep scan, you're more than likely to see results. It'll also do a secure overwrite, if you're looking to do the opposite.
www.piriform.com

23

BACKUP

EASEUS TODO BACKUP FREE

Selective, automatic, and easy. EaseUS's solution to backup is probably the most sensible we've seen. You can plug in an external drive (or point it at a NAS), and just set and forget—it periodically creates an incremental backup of your selected folders (or those it's chosen using its smart backup feature), without any more involvement from you. If you want to take a more specific backup, you can, and restoring later on is incredibly easy.
www.easeus.com

WEB BROWSERS

24

GOOGLE CHROME

Whatever you might think of Google, its browser—and the open-source Chromium browser that it's built upon—deserves its place at the top of the tree. It makes big demands on your RAM, but this is because it keeps every one of its tabs in its own memory space, meaning a crash in one window won't kill any of the others. There's a massive extension library ready to go, so you can browse exactly as you'd want to—although not every extension is worth the bits it's made of....
www.google.com/chrome

25

FIREFOX

Far better than it was before it fell off the top spot, Firefox is now a highly efficient browser that's kinder on your RAM than Chrome, and—depending on your browser habits—potentially more stable, too. Running modern Firefox is a speedy experience, and if you're looking for privacy, you can do a lot more by default than Chrome's incognito mode—the anti-tracking features Mozilla has packed in are perfect for those desperate to leave a light footprint on the web.
www.mozilla.com

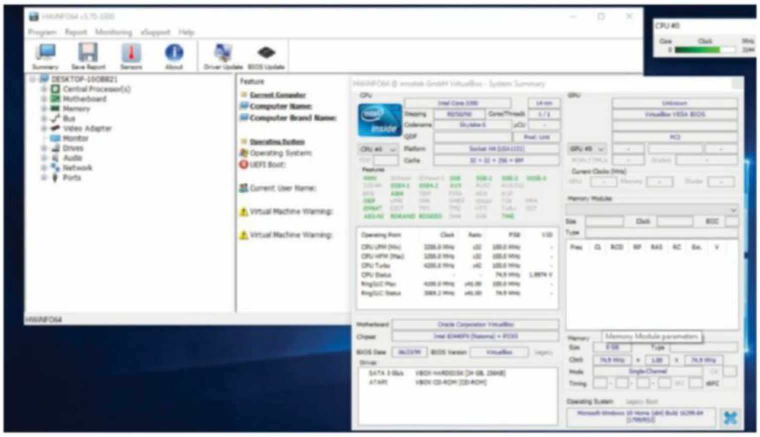
26

VIVALDI

You might place Opera in the number three free browser slot; we're going for Vivaldi, the browser that formed from disillusion with Opera's practices. It's a truly modern browser, using the same rendering engine as Chrome, and many of the key features of Opera, while tacking on a host of note-taking, tab-managing, experience-modifying features. There's a dedicated community driving the Vivaldi project on, and you can even use certain Chrome extensions.
http://vivaldi.com

VIVALDI
A Browser for Our Friends
FREE DOWNLOAD
Speed Dial

SYSTEM UTILITIES



HWiNFO64 enables you to get to know your PC intimately, and pinpoint potential problems.

27

PDF READER

SUMATRA PDF

Adobe needn't have the monopoly on PDF reading. The format is far more widespread than it once was, and there are smaller, faster, and more versatile readers than, er, Reader—SumatraPDF being the best among them. It has a deliberately simple UI, because you're meant to be focused on reading, rather than clicking buttons, and also includes full support for rendering most mainstream ebook and comic book formats, as well as XPS and DjVu files.

www.sumatrapdfreader.org

28

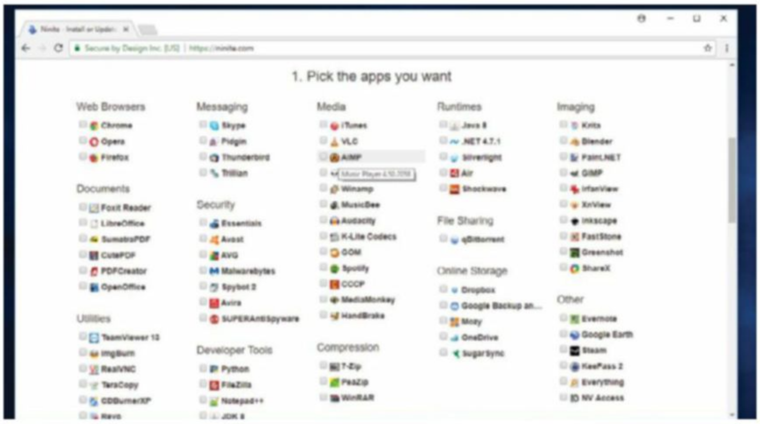
EMAIL CLIENT

EM CLIENT

One of the cleanest email packages around, working with POP3, SMTP, and every other email delivery tech out there, eM Client's free version only really restricts the number of accounts you can use—every other feature matches up to its pro tier. This includes PGP integration, so you can securely sign or encrypt your messages, along with advanced contacts management, importing from other email apps, and a chat client that supports most common IM protocols.

http://emclient.com

Set up a system with ease, and let Ninite handle the job of installing free apps.


1. Pick the apps you want
Web Browsers
Chrome
Opera
Firefox
Documents
Foxit Reader
LibreOffice
SumatraPDF
CutePDF
PDFCreator
OpenOffice
Utilities
TeamViewer 13
ImgBurn
RealVNC
TeraCopy
CDBurnerXP
Revo
Messaging
Skype
Pidgin
Thunderbird
Trillian
Security
Essentials
Avast
AVG
Malwarebytes
Spybot 2
Avira
SUPERAntiSpyware
Developer Tools
Python
FileZilla
Notepad++
JDK 8
Media
iTunes
VLC
AIMP
Winamp
MusicBee
Audacity
K-Lite Codecs
GOM
Spotify
CCCP
MediaMonkey
HandBrake
Compression
7-Zip
PeaZip
WinRAR
Runtimes
Java 8
.NET 4.7.1
Silverlight
Air
Shockwave
File Sharing
qBittorrent
Online Storage
Dropbox
Google Backup an...
Mozy
OneDrive
SugarSync
Imaging
Krita
Blender
Paint.NET
GIMP
IrfanView
XnView
Inkscape
FastStone
Greenshot
ShareX
Other
Evernote
Google Earth
Steam
KeePass 2
Everything
NV Access

29

FILE SYNCHRONIZATION

DROPBOX

Keeping files synched between your many PCs and an online drive is a simple way of staying organized and safe, and it's not without its options. Google Drive, Microsoft OneDrive, Box, even Mega, they all give you a local folder that automatically mirrors one online. We favor Dropbox for this task, mainly because it feels like the most responsive and sensible way to magically clone your stuff. It's what DropBox was built to do—limited storage space be damned.

www.dropbox.com

30

MEDIA BURNER

CDBURNERXP

Optical media is a progressively more marginal form of storage, but it ain't dead yet, and the flexibility to do more than Windows' own built-in burning tools is essential. CDBurnerXP, which shows its lineage in its name, can burn it all—you can even use it to write HD-DVDs if you can find the hardware—and it can create and convert ISO files, too. Perfect for backing up backups.

http://cdburnerxp.se

31

MESSAGING

FRANZ

Franz doesn't actually offer its own messaging system, but it does serve up just about every other protocol. Configure your Franz account, add the services and usernames you want to use, and they're replicated on whatever machine you log on to next. Get your Slack, your Hangouts, your Skype, and even WhatsApp all in one place, and stop shunning that one person who won't move to the network the rest of your friends use.

http://meetfranz.com

32

NOTES

EVERNOTE

The great benefit of being the biggest name in your field, as Evernote surely is, is integration. So many other web services tie into

it that you often don't need to make notes directly—just chuck the content you're interested in over to your Evernote, and it's there when you want to remember, organize it into notebooks, and otherwise make use of it later on. You can sync the basic free account with two devices.
http://evernote.com

33

UTILITY SETUP
NINITE

Efficiency is the name of the game where Ninite is concerned. If you're putting together a new machine, and you want it packed with free apps, Ninite can supply them—including many of the apps featured here—in one handy installer. Just check the boxes on the site, download your custom executable, and fire it off to get the latest versions of the most popular applications installed with one click. No choices, no options, just clean installs of your favorite stuff.
http://ninite.com

34

VIRTUAL MACHINES
VIRTUALBOX

It's sort of remarkable that VirtualBox is free, particularly since it's owned by a company as large as Oracle, but the frequently updated virtual machine environment is essential if you want to cobble together sandboxed Windows installs, trial Linux distros, or do all kinds of shenanigans that it might be useful to roll back or keep separate from the rest of your PC. It's highly configurable, and you can even set up your own virtual networks.
www.virtualbox.org

35

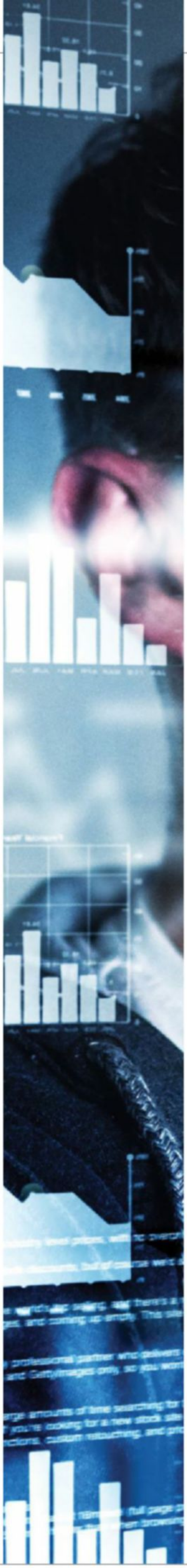
SYSTEM INFO
HWINFO64

If you have a problem with your PC—or even if you don't—it's useful to find out exactly how it's operating. HWiNFO64 is a diagnostic tool that can serve up everything from a brief overview of your system's components to a deep dive into the minuscule operations of your PC. You can also use it for real-time monitoring, keeping an eye on the status of problem components, and predicting failure based on its findings.
www.hwinfo.com

36

COMPRESSION
7-ZIP

We find it pretty amazing how many people have the never-ending free trial of WinRAR installed when 7-zip does the job of archiving and unarchiving just as competently, and doesn't bother with the nag screens. What's more, the .7z format, which uses AES-256 encryption and a super-high compression ratio, is both smaller and, usually, faster than using .ZIP or .RAR to squash down your files.
www.7-zip.org



OFFICE SUITES

37

GOOGLE DOCS

Although it's missing many of the more advanced features of full office suites, those are generally things you shouldn't be using an office package for anyway. Google Docs—and Sheets, and Slides—rocks a winning combination of solid core features, constant accessibility, integration with online storage, and companion mobile apps, which (awkwardly) offer you the same functionality on your phone. You can import and export in any format you choose—what's not to like?
http://docs.google.com

38

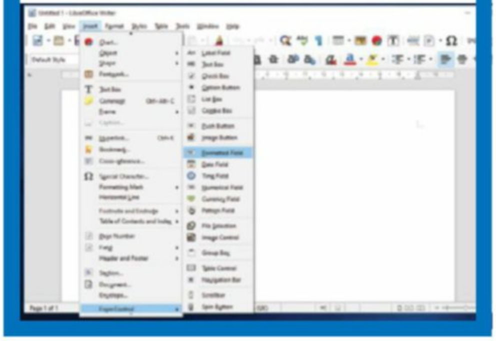
APACHE OPENOFFICE

One of many successors of original Microsoft Office alternative StarOffice, OpenOffice (passed on to Apache after previous owner, Oracle, abandoned the project) contains a complete suite of software, ranging from the core word processor/spreadsheet/presentations triumvirate to software specifically designed for vector drawing, laying out mathematical formulae, and a database. If you're not shelling out for Microsoft's suite, this'll get the job done.
www.openoffice.org

39

LIBREOFFICE

LibreOffice is, somewhat naturally, just like OpenOffice—while the two packages have followed different development lines since mid-2013, they're based on the same code, and retain the same naming convention (and, in most cases, a very similar interface) for their central six apps. It's up to you which free office branch you follow; ignoring the frequent squabbling that split the two (and fellow StarOffice fork NeoOffice), they're just as capable as one another.
www.libreoffice.org ⏻



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MAXIMUMPC
2018 TECH PREVIEW
Revealed Next-gen hardware that will transform your PC, from AMD, Intel, Nvidia, & more PG. 26
MAXIMUMPC
NO.1 FOR PC HARDWARE
BEST RAM UPGRADES
Memory specs and settings explained
AMD and Intel rigs benchmarked
How much do you need?
BUILD IT
39 TOP FREE WINDOWS APPS

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TECH PORN

RIGHT
1624
MADE IN JAPAN
audio-technica
ATH-A2000Z

1 DYNAMIC

The A2000Zs feature proprietary 53mm, large aperture, closed-back, dynamic drivers, producing a staggering 5–45,000Hz frequency response, and a sensitivity of 101dB/mW. There's no sound, certainly not within human hearing, that these can't reproduce.

Audio-Technica ATH-A2000Z

WE COULD WAX LYRICAL about the graceful flowing streams of audio fidelity produced by the ATH-A2000Zs, the clarity of exuberant treble's touch upon the human soul, or how no true price can be put upon musical sublimity, but let's be real for a moment: That technological verbosity is best left to the marketeers, PRs, and mouthpieces paid to promote such laboriously designed products.

In our eyes, such talk is nothing but a disservice to the thousands of hours and hard work the artisans at Audio-Technica have put into creating these wonderful masterstrokes. And no amount of verbal adulation, albeit apt, can convey better than the headphones themselves just how impressive they are.

The ATH-A2000Zs are not in any way affordable. And for most people, they make little sense. They are a premium indulgence, designed to produce the best sound possible. They effortlessly exude a balanced, wide and enjoyable soundscape to those with keen enough ears. But that's subjective, of course. All we'll say is this: We wholeheartedly recommend these headphones. **–ZAK STOREY**

2 COMFORT

Audio-Technica's near-iconic headband solution is by far one of the most comfortable designs we've ever tried, reducing both weight and pressure on top of your skull, so overall fatigue is minimal. It's self-adjusting, too, making it easy for anyone to enjoy quality audio on the fly.

3 AIR DAMPING

A-T's Double Air Damping System (or DADS for short) helps the closed-back design feel far more open than traditional styles. By increasing the distance between the driver and the eardrum, it allows both low and mid-range frequencies room to resonate within the chamber before hitting your ear. The result is stunning.

BEATING THE NSA

Keep it secret, keep it safe; but you don't need to encode your most secret of messages on an all-powerful gold ring—we have the power of full-disk encryption, and *Maximum PC* as your guide

WE LOVE TELLING YOU to do boring stuff with your state-of-the-art PCs: back up your files, update Windows, use strong passwords.... Now you can add another one to the list: encrypting your hard drive. But wait, don't turn the page, we're here to show you how full-disk encryption is easy, while ensuring those rascals at NSA HQ can't access your data without your say-so (precluding any legally permissible enhanced interrogation techniques that our friends in the Department of Defense feel are appropriate).

Turned your cell off and popped on your tinfoil hat? Let's carry on... By default, the files on your Windows PC are accessible to anyone with physical access to it. If you use a local Windows account, it's trivial to reset the password and gain administrator access; a suitably motivated attacker could even reset an online account if they know some personal details.

Sure, for your Steam game files, who cares? But do you really want sensitive documents, accounts, and more accessible to all? And if you junk an old system, toss a drive, or lose a USB stick, if someone random picks it up, do you want them to be able to read every file? Here comes full-disk encryption to the rescue!

1617
1619

IN THIS GUIDE, we're going to take you through encrypting entire drives. This includes the main scenarios, utilizing the most widely used solutions—of which we're sticking with just two. To kick things off, we're looking at the Microsoft-supplied option, because surely that's the best option, right? We'll toss in a few opinions on that further into the article.... As for scenarios, we're looking at full-disk encryption for a data disk, removable drives for a container drive file, and finally lead you through setting up your boot drive with encryption, which is really the important one.

As for software, you've probably guessed that the Microsoft solution is its long-standing BitLocker system, which we're covering first. We then move on to something far more flexible, but a touch more complex, in the form of VeraCrypt. Both have their plus and minus points, but they're not mutually exclusive either, so it's not even a case of choosing one or the other, more picking what works best for you.

As for encryption technology itself, we're not going to get bogged down with the technicalities here. Even the basics might as well effectively be magic to most people who don't have a PhD in the field of cryptography. We should also dismiss any concerns about performance; similar to compression, it's the initial encrypting that takes the time (even this can be done on the fly and in the background while you work), while the decryption costs a minimal performance hit—around one percentage point—in even oldish processors (going back to Intel's 2010 Nehalem range, and AMD's 2011 Bulldozer range onward) utilizing dedicated hardware acceleration via AES commands.

BITLOCKER LAID BARE

Introduced with Windows Vista, BitLocker is seen by Microsoft as an enterprise-level feature, so it's only available on Enterprise, Ultimate, and Pro editions of its operating systems. It's likely you're running Windows 10 Pro, so you're good to go. If not, you can either opt to upgrade your version of Windows or, more sensibly, skip ahead to the section on the freely available open-source VeraCrypt.

The other major requirement for encrypting the OS boot drive is a system equipped with a Trusted Platform Module (TPM)—it's not essential, because BitLocker can fall back to using a USB key to store the decrypt key, which you may or may not want to do. The TPM is typically part of the motherboard, and is a bit of cryptographic magic that securely stores the decrypt key and maintains the system's chain of trust, among other things.

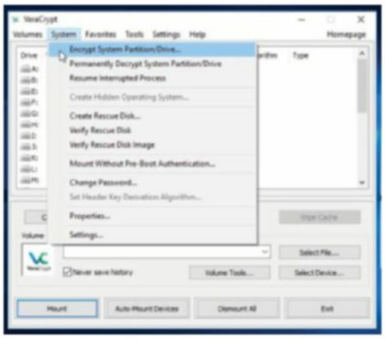
Why is a TPM so important, and why so many options? During the boot process, there's a chain of trust—how do you know that none of the parts involved in starting your PC have been compromised by malware, rootkits, or another evil actor? This goes for the motherboard's BIOS firmware, the bootloader, Windows kernel components, and software running on your system. Every stage needs to be protected; all software components should be signed with a secure key and checked via Secureboot. If a driver or module isn't signed, it's not loaded. If the drive is removed and placed in another system, the original TPM won't be found, and your system won't boot; if the TPM is taken, it'll refuse to work in another system. The TPM is designed to be an unwavering guardian of that trust, which flags up any changes in that chain. Enough of this, though, because we're here for just the encryption, rather than a full-on privacy or infosec feature.

To check whether your system has BitLocker and a TPM, open the Start menu, type "bitlocker" and click the Control Panel option—if there's no BitLocker, you're not running a suitable version of Windows. In the BitLocker window, you should

AN ENCRYPTED BOOT DRIVE IN 10 TROUBLE-FREE STEPS

Let's go through the process of setting up an encrypted system boot drive with VeraCrypt. Be warned: There is no recovery process. If you lose or forget your password or keyfile, even the FBI can't help you get your data back.

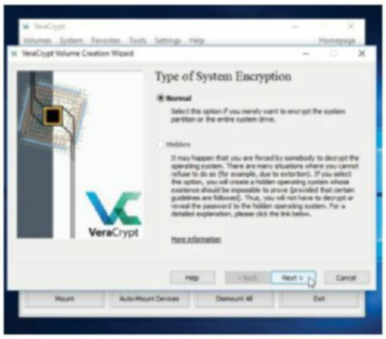
1


VeraCrypt
Volumes
System
Favorites
Tools
Settings
Help
Homepage
Encrypt System Partition/Drive...
Permanently Decrypt System Partition/Drive
Resume Interrupted Process
Create Hidden Operating System...
Create Rescue Disk...
Verify Rescue Disk
Verify Rescue Disk Image
Mount Without Pre-Boot Authentication...
Change Password...
Set Header Key Derivation Algorithm...
Properties...
Settings...
Drive
Type
Volume
Wipe Cache
Select File...
Never save history
Volume Tools...
Select Device...
Mount
Auto-Mount Devices
Dismount All
Exit

GET AND INSTALL

For this guide, we're going to be using VeraCrypt, which lives at www.veracrypt.fr, so get yourself over to the website, go to the "Downloads" tab, then select the EXE file for Windows systems. Run the installer, ensuring you choose the "Install" option, because that's the only way it will encrypt your boot drive. Fire up the program, then go to the "System → Encrypt System Partition/Drive" menu.

2


VeraCrypt
Volumes
System
Favorites
Tools
Settings
Help
Homepage
VeraCrypt Volume Creation Wizard
Type of System Encryption
VeraCrypt
More information
Help
< Back
Next >
Cancel
Mount
Auto-Mount Devices
Dismount All
Exit

● Normal

Select this option if you merely want to encrypt the system partition or the entire system drive.

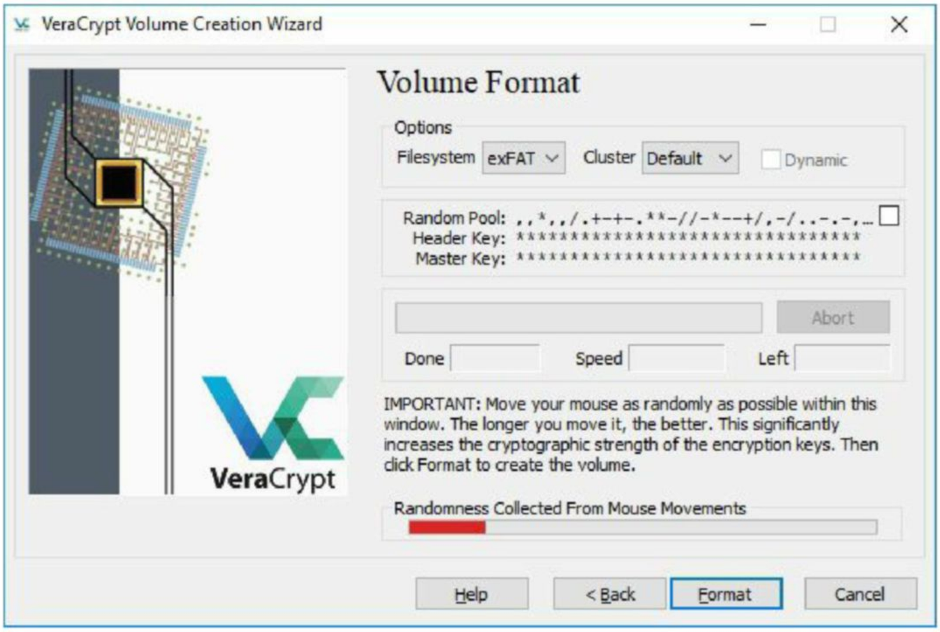
○ Hidden

It may happen that you are forced by somebody to decrypt the operating system. There are many situations where you cannot refuse to do so (for example, due to extortion). If you select this option, you will create a hidden operating system whose existence should be impossible to prove (provided that certain guidelines are followed). Thus, you will not have to decrypt or reveal the password to the hidden operating system. For a detailed explanation, please click the link below.

HIDDEN OR NORMAL

Before you can start the process, there's the option of creating a "Hidden" system partition—you won't want to do this. It's handy to know about, though, because it enables you to decrypt the drive under duress, and retain plausible denial. We're not going to cover this, because it requires additional tweaking to have it work comprehensively, so we'll just concentrate on the standard "Normal" option.

CONTAINER FILES


VeraCrypt Volume Creation Wizard

Volume Format

Options

Filesystem: exFAT Cluster: Default ☐ Dynamic

Random Pool: ,.*,,/.+-+-.**-//-*--+/,-/..-.-,..

Header Key: ******************************

Master Key: ******************************

Done Speed Left

IMPORTANT: Move your mouse as randomly as possible within this window. The longer you move it, the better. This significantly increases the cryptographic strength of the encryption keys. Then click Format to create the volume.

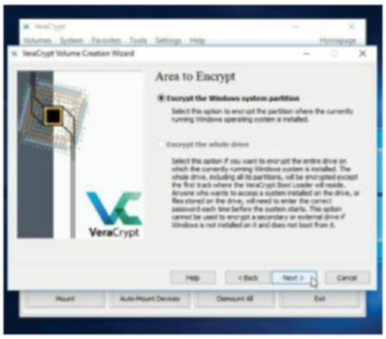
Randomness Collected From Mouse Movements

In the walkthrough, we cover creating an encrypted system boot partition. Encrypting a data partition or drive is very similar, minus the recovery and rebooting steps. Click “Create Volume” in the main VeraCrypt interface, and select “Encrypt a non-system partition/drive.” There is a third option: “Create an encrypted file container.” This is a flexible way to store protected data on a fixed drive or removable device. It’s a large file that can grow in size (on NTFS devices) when needed, and that VeraCrypt mounts as a standard Windows drive.

Choose to create one, pick a location and filename (you can move or rename it later), choose an initial size, and select the “Dynamic” option, so it resizes on the fly. As it’s mounted as a drive, VeraCrypt needs to format it with a filesystem (NTFS is best), and create some entropy for security.

Next, you need to mount this new file. In the main VeraCrypt window, click the “Select File” button, and locate your container file—subsequently, this is available in the “Volume” pull-down menu on the left, unless you select not to save the history. The file grows up to the maximum you entered; even so, you can expand this at any point using the “Tools → Volume Expander” menu.

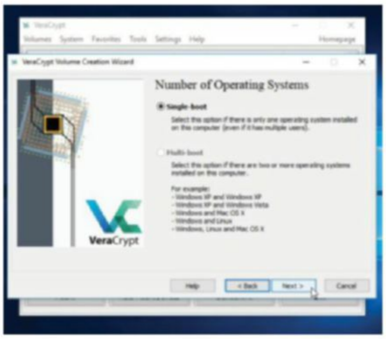
3



DRIVE OR PARTITION

For our system, the only option here is the Windows partition. It’s likely that if you’re running Windows off an SSD, you’re using the whole drive for Windows, so you’ll have the same situation. Use the “Encrypt the whole drive” option to do just that in one go. If you’re after protecting all of your files, this is probably the easiest option to choose; protecting partitions separately does enable you to use different passwords and keyfiles.

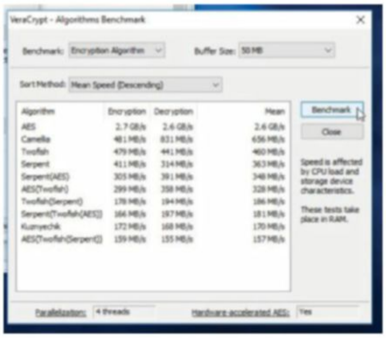
4



MULTI-BOOT NONSENSE

We live in crazy times—apparently, people can use more than just Windows 10 on their PCs! There are older versions of Windows for your dad to complain about; people who sit in coffee shops use something called Mac OS X; and we hear the hacker 4chan uses an OS he wrote himself, called a Linux. Choose and perish. The bootloader that VeraCrypt installs can handle all of these and more. Again, we won’t be doing that here.

5


VeraCrypt - Algorithms Benchmark

Benchmark: Encryption Algorithm Buffer Size: 50 MB

Sort Method: Mean Speed (Descending)

Algorithm	Encryption	Decryption	Mean
AES	2.7 GB/s	2.6 GB/s	2.6 GB/s
Camellia	481 MB/s	831 MB/s	656 MB/s
Twofish	479 MB/s	441 MB/s	460 MB/s
Serpent	411 MB/s	314 MB/s	363 MB/s
Serpent(AES)	305 MB/s	391 MB/s	348 MB/s
AES(Twofish)	299 MB/s	358 MB/s	328 MB/s
Twofish(Serpent)	178 MB/s	194 MB/s	186 MB/s
Serpent(Twofish(AES))	166 MB/s	197 MB/s	181 MB/s
Kuznyechik	172 MB/s	168 MB/s	170 MB/s
AES(Twofish(Serpent))	159 MB/s	155 MB/s	157 MB/s

Speed is affected by CPU load and storage device characteristics.

These tests take place in RAM.

Parallelization: 4 threads Hardware-accelerated AES: Yes

ENCRYPTION BENCHIES!

VeraCrypt offers a full range and combination of encryption algorithms and hashing schemes. Stick with the default, which is the industry standard AES and SHA-512. Why are we being so mean? Hit the “Benchmark” button and you’ll see your hardware acceleration kick AES to the top of the list by at least fourfold, if not by a factor of 10 or more. The same goes for the hashing system; vanilla default is the tastiest!

see a list of drives (these should claim BitLocker is off)—ignore these. Click "TPM Administration" in the bottom-left to see if you have a TPM-enabled system. If not, but you think you do, boot into the BIOS/UEFI, and look for an option to enable the TPM.

Let's assume you do have a TPM. Click "Turn BitLocker on" next to the drive in question. To initiate and activate the TPM, Windows has to reboot. Once back, you need to create a boot PIN, password, or USB key—this is used before Windows will even start loading. Next, a recovery key has to be created in case you forget your password, the USB key explodes, or is left on a train. This can be saved as any or all of these options: to your cloud-based Microsoft account, to a file, on a removable drive, or printed out. The encryption is about to begin. Windows offers two approaches: encrypt every byte on the drive, or only used data. The latter is quicker, but doesn't protect deleted data; the former can take a while. The process is done in the background, though, so time may be irrelevant.

Finally, your Windows 10 PC asks if it should use New or Compatible mode. For fixed drives, choose "New." For removable drives using On The Go, you might want to choose "Compatible" if the drive will be used on older Windows versions. Windows now checks compatibility, configures your system, then reboots (using the new login security), and you're done; the drive begins encryption. For data drives and removable media, no TPM is required—just click, create a password, and go.

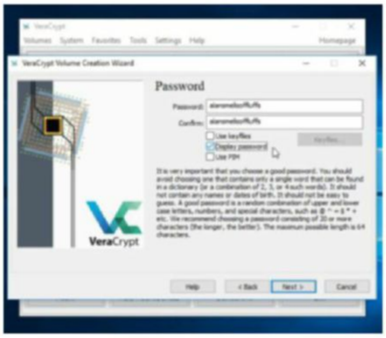
Finally, we mentioned you don't need a TPM to encrypt the boot disk with BitLocker. If you try, you get an error suggesting you add a policy to enable this, but no instructions. To do this, type "gpedit.msc" in the Search box, and hit Return. In the tree directory, navigate to "Local Computer Policy → Computer Configuration → Administrative Templates → Windows Components → BitLocker Drive Encryption → Operating System Drives." Double-click "Require additional authentication at startup," choose "Enabled," and select "Allow Bitlocker without a compatible TPM" in the "Options" box. Click "OK." You can now proceed using a USB key or password.

THE VERACRYPT VERSION

That was the pretty straightforward (bar the TPM issues) Microsoft solution. But we can do better, can't we? Allow us to introduce VeraCrypt. If the name sounds familiar, it's because it's the spiritual and source-code successor of TrueCrypt, which was a long-standing and widely used drive encryption tool, going back to 2004. If you were wondering what happened to it, the project was shuttered out of the blue at the end of May 2014. A message urged people to move to BitLocker, and a decrypt-only version was released. Conspiracy theories circulated suggesting the developers had been hit with an NSA gag order, and forced to implement a back door. However, a full source audit found no serious flaws or back doors, and one of the developers named "David" stated in 2015 the reason was that "there is no longer interest [in maintaining the project]."

Why do we like VeraCrypt if Microsoft has a perfectly functional BitLocker solution? Because it's open source, so we know it's safe to use, without back doors. VeraCrypt is also portable; it offers an extract-only mode (which won't work on the boot OS partition) that you can copy on to an external drive, and take anywhere. It's also available for Windows, Mac OS X, BSD, and Linux, so encrypted drives or container files can be read by almost anything. It's also super-flexible, with modes for data drives, the boot partition, removable drives, hidden drives, and flexible container files. There's no need for a TPM, while there are options for any combination of passwords, keyfiles, smart cards, and so on. Our 10-step walkthrough explains the rest. ⏻

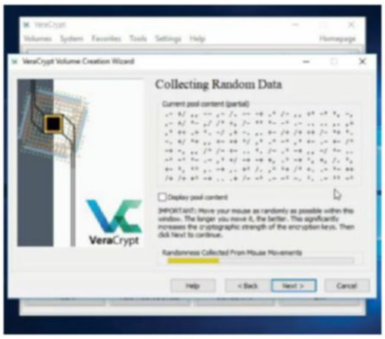
6



PASSWORD

Before you can go any further, you need to set a strong but memorable password. Take a quick look at www.xkcd.com/936 for a simple explanation of password strength, aka entropy. You're going to enter this password every time you boot, so making it memorable would be useful. Unfortunately, keyfiles can't yet be used for system boot drives, which makes us sad, because they're great (see the boxout, above-right).

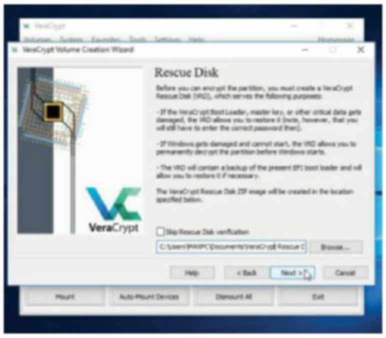
7



GATHERING ENTROPY

The next part of the process might seem a little odd, but that's because of the complexity of generating true randomness that digital systems struggle to do. You'll need to move your mouse around erratically to generate enough "entropy" for VeraCrypt to generate a truly random set of keys—the longer you move it, the better, but you can hit "Next" at any point. The keys are then created in the next step.

8



RESCUE DISK

We cover the rescue process in the boxout on the right, but this is the stage where you create the data files. This contains a duplicate of the existing EFI bootloader, so you can restore everything back to how it was—be aware you still need your password to decrypt the data; there is no recovery for that. VeraCrypt insists you extract the created ZIP file to the root of a USB drive that's formatted to FAT or FAT32. So do that.

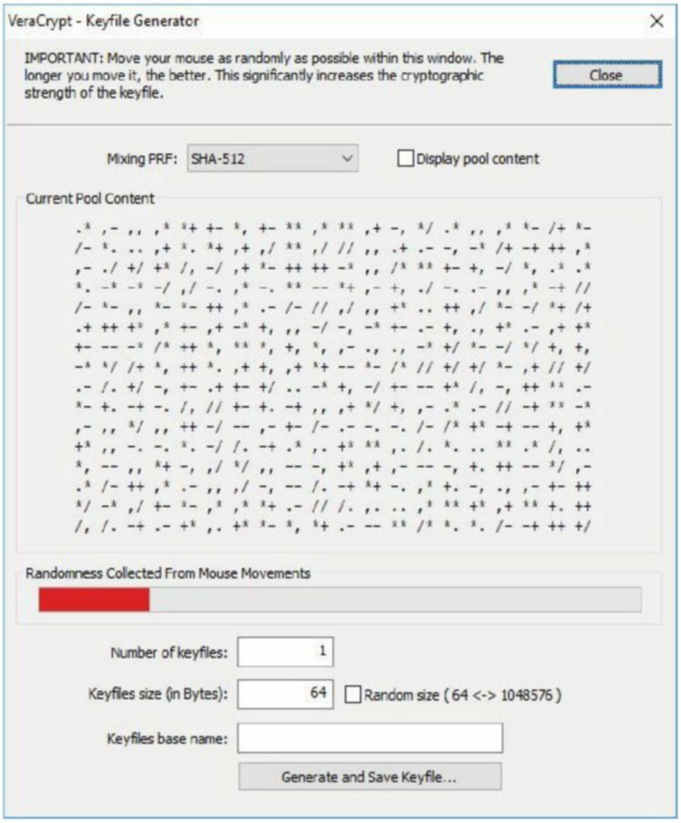
KEYFILE DEFENSE

We mention keyfiles in the 10-step walkthrough below, largely to say that they don't work with a system boot drive. However, keyfiles are one of the best ways to improve your encryption security, because they add a second factor of authentication to the procedure—you need both your password and the keyfile (which can be stored anywhere) before VeraCrypt is able to decrypt your data drive or container file.

Keyfiles are useful because they boost security, especially if you're using a weak password. Enable multiple people to access the same file—don't use a password, just give them all the same keyfile—and it enables shared access when multiple people want a file protected; multiple different keyfiles can be used to lock a volume, and all must be present to open it.

Technically, you can use any file as a keyfile: that MP3 over there, that icon file here, or a photo you've taken. VeraCrypt only uses the first 1,024kb of the keyfile, so do be wary; it might sound clever using an image or MP3 file, but if a single bit changes (something re-encodes the JPEG or MP3) in that first 1,024kb, you lose all access to the encrypted volume. Keyfiles can also be generated for you, which is a little more sensible.

When you come to mounting a volume, just point VeraCrypt at where the keyfile is stored. This could be on a local drive, the desktop, a network share, or a removable USB drive. You'll want to keep a backup somewhere secure, just in case you lose it.


VeraCrypt - Keyfile Generator

IMPORTANT: Move your mouse as randomly as possible within this window. The longer you move it, the better. This significantly increases the cryptographic strength of the keyfile.

Mixing PRF: SHA-512

☐ Display pool content

Current Pool Content

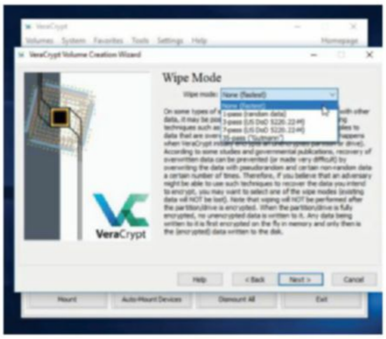
Randomness Collected From Mouse Movements

Number of keyfiles: 1

Keyfiles size (in Bytes): 64 ☐ Random size (64 <-> 1048576)

Keyfiles base name:

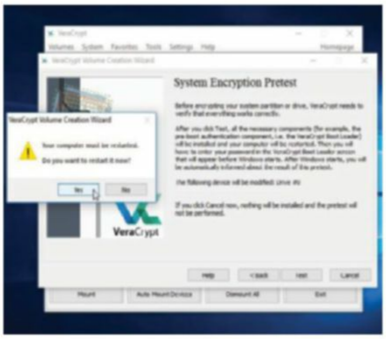
9



WIPE MODE

Engage paranoia mode! VeraCrypt offers to wipe the drive with semi-random data to avoid attackers recovering data from it. You are most probably in the happy position that this isn't an issue, so can select "None." Even if you are paranoid, a single pass on modern drives permanently removes data. The "35 times" urban myth was from a study done on ancient IBM-style Winchester drives, and is no longer applicable.

10



TEST AND GO

The highly paranoid VeraCrypt is all but set to go. It insists on running through a test cycle to ensure the new bootloader is working correctly before it encrypts your data. You need to enter the password, and Windows boots. If it doesn't, read the "Don't Panic" box on the right. Back in Windows, you can start the encryption process, and we're done! You do this at your own risk; if you forget your password, your data is irretrievable.

DON'T PANIC! (PERHAPS A BIT)

During the test reboot, if Windows fails to start or your password isn't accepted, restart the PC, and press Escape at the VeraCrypt login screen. If you have a multi-boot system, choose Windows, else it just starts, and you can choose to remove the bootloader.

If the bootloader isn't appearing, you need to boot from the rescue disk you created (you did, didn't you?). Insert your USB stick or CD, and wait for the rescue screen. If it doesn't appear, you need to change the boot device. Many systems offer a boot menu accessed by tapping F9 (HP), F12 (Dell, Lenovo), F8 (Amibios), or F11 (Award BIOS) while booting.

The VeraCrypt Rescue Disk screen should now appear. Select "Repair Options" by pressing F8 on your keyboard, then select the "Restore original system loader" option. Remove the rescue disk, and restart your computer. Windows should start normally (provided that it is not encrypted).

Note that the previous steps do not work if the system partition or drive is encrypted. Nobody can start Windows or access encrypted data on the drive without the correct password, even if he or she follows the previous steps.

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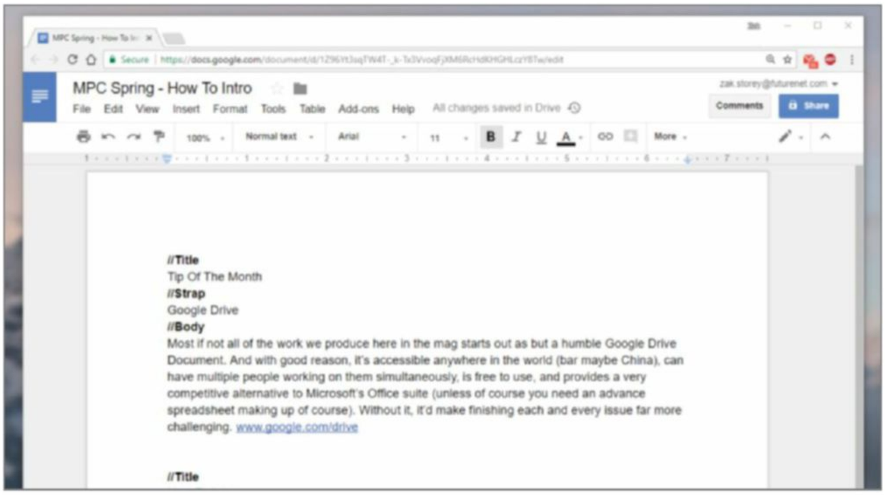
HOW TO

STEP-BY-STEP GUIDES TO IMPROVING YOUR PC

TIP OF THE MONTH


MPC Spring - How To In
Secure https://docs.google.com/document/d/1Z96Yt3sqTW4T-_k-Tx3VvoqFjXM6RcHdKHGHLczY8Tw/edit
MPC Spring - How To Intro
File Edit View Insert Format Tools Table Add-ons Help All changes saved in Drive
zak.storey@futurenet.com
Comments
Share
100% Normal text Arial 11 More

//Title
Tip Of The Month
//Strap
Google Drive
//Body
Most if not all of the work we produce here in the mag starts out as but a humble Google Drive Document. And with good reason, it's accessible anywhere in the world (bar maybe China), can have multiple people working on them simultaneously, is free to use, and provides a very competitive alternative to Microsoft's Office suite (unless of course you need an advance spreadsheet making up of course). Without it, it'd make finishing each and every issue far more challenging. www.google.com/drive

//Title

GOOGLE DRIVE

Most, if not all, of the work we produce for the mag starts out as a Google Drive document. And with good reason: It's accessible anywhere (bar maybe China), can have multiple people working simultaneously, is free to use, and is a competitive alternative to Microsoft's Office (unless you need an advanced spreadsheet, of course). Without it, finishing each issue would be far more challenging. www.google.com/drive

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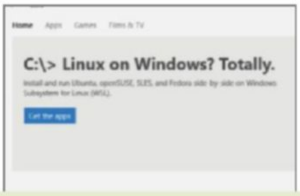
Or choose your operating system
Windows
Linux (tgz)
Windows (zip)
ARM Linux
Mac OS X
Ubuntu (PPA)
Verify release signatures
Download torrent

58
Set up and run your own full Bitcoin node


Home Apps Games Films & TV
C:\> Linux on Windows? Totally.
Get the apps

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Use the Ubuntu Linux distro from within Windows 10

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The pain and pleasure of building an ITX machine

ZAK STOREY
DEPUTY EDITOR

ZERO-POINT PROGRESSION

Here at *Maximum PC*, systems are a big deal. We rarely have an issue that doesn't feature a build or a system review. They're integral to the magazine and important to all of us enthusiasts. The thing is, our zero-point benchmarks are starting to look a little antiquated and broken.

The theory, up until now, was to use a single mid to high-end build (around $2,400), and bench it at 1080p for all our testing (because 1080p is still the most common resolution). Problem with that is that when it gets compared to 4K pixel-punching powerhouses from the likes of Digital Storm and co, it looks crappy. And when it goes up against our $300–700 budget builds, it wipes the floor with them. The result: It doesn't actually tell us much.

So, what's the answer? Three zero-point systems. Yup, that's right. Each at a separate price point. Each with wildly different specs. We've decided to introduce the new zero-points alongside our new benchmarking suites, just to keep things fresh. You can find out more about our new benchies and zero-points on pages 92 and 93. (I've hijacked Lab Notes this issue! Sorry, guys!)

We'll also be updating our notebook zero-points. Again, they will better represent various sectors of the market—after all, comparing a 1440p gaming laptop to a 1080p workbook doesn't make a whole lotta sense.

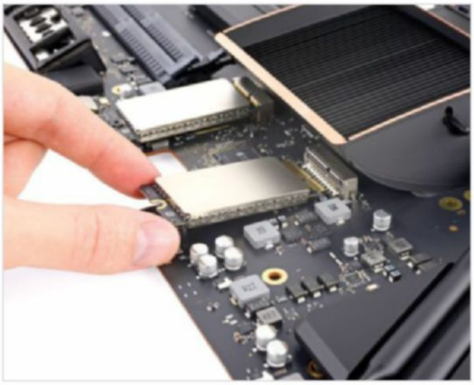
↘ submit your How To project idea to: comments@maximumpc.com

IFIXIT presents:

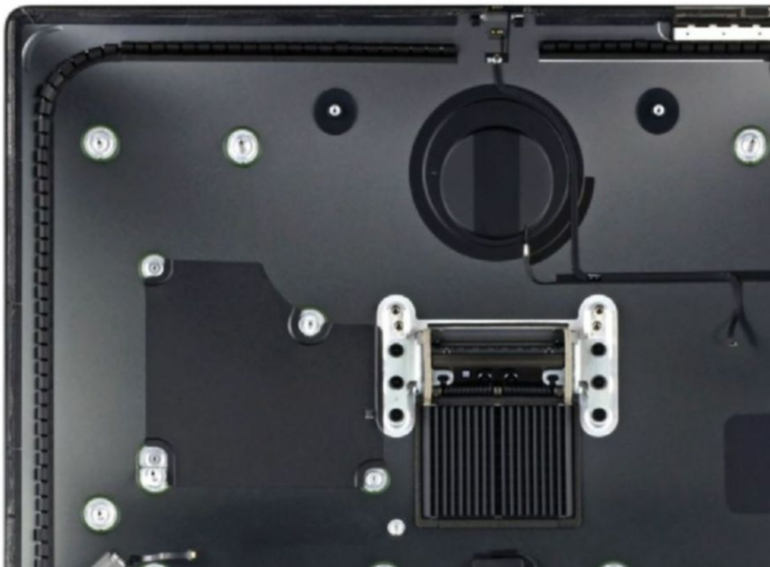
AUTOPSY

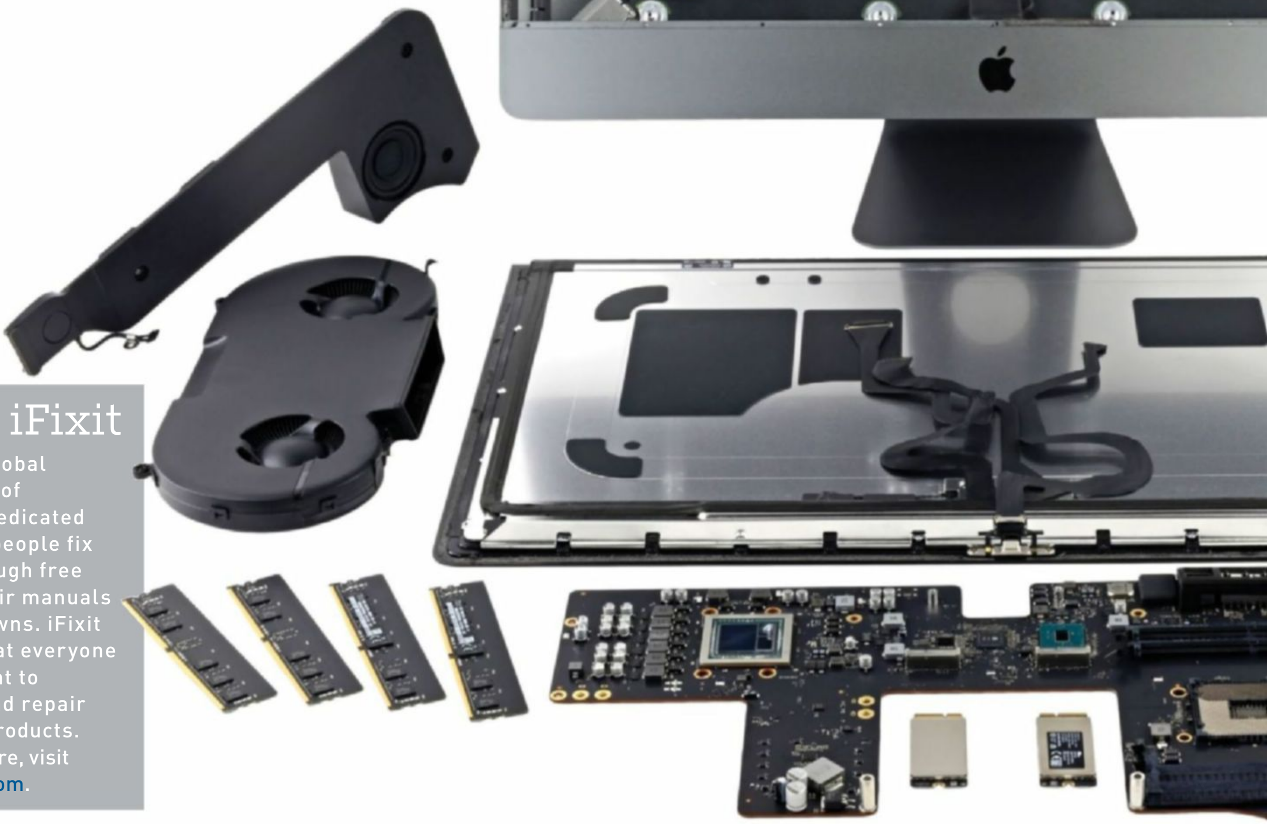
THIS MONTH WE DISSECT...

Apple iMac Pro



Unfortunately, the SSDs still use a proprietary connection standard.





About iFixit

iFixit is a global community of tinkerers dedicated to helping people fix things through free online repair manuals and teardowns. iFixit believes that everyone has the right to maintain and repair their own products. To learn more, visit www.ifixit.com.

It's almost like a real PC—you can change the memory and everything.

BACKGROUND

We dropped $4,999 to get our hands on the hot new space-gray Magic Mouse and Magic Keyboard—and Apple was generous enough to throw in a brand-new iMac Pro for no extra charge! Let's take it apart and see what makes it tick.

MAJOR TECH SPECS

- Eight-core, 3.2GHz Intel Xeon W processor, with Turbo Boost up to 4.2GHz
- 32GB (4x 8GB) of 2,666MHz DDR4 ECC
- AMD Radeon Pro Vega 56 GPU with 8GB of HBM 2.0 memory
- 27-inch display with 5120x2880 resolution and support for one billion colors (P3 color gamut)
- 1TB SSD

KEY FINDINGS

- We're betting the opening procedure will be the same as it was on the iMac 5K—which is to say, if you can use a pizza cutter, you can open an iMac Pro. With all that glass out of the way, we have a perfect view of the iMac Pro's pristine interior. It would make a lovely wallpaper for someone.
- The first component out is the enormous dual-fan cooler. Looks like Apple sacrificed the 5K's full-size desktop hard drive (not that you'd want that in a pro machine) to make some room here. Also sacrificed to the cooling gods: the external RAM access hatch. Sad face. In exchange, we get a big rear vent and an 80 percent increase in cooling capacity.
- The power supply connects to the logic board by way of not one, not two, but four shiny terminals secured with Torx screws. This design is much closer to what we saw on the 2013 Mac Pro than the plasticky connectors we're used to ripping out of the iMac 5K. It also makes accessing logic board components (apart from the RAM, of course) much, much easier. With the power supply tucked back into the rear shell, we can remove the board right away.
- Time to take a closer look at that display. Turns out it's the same display panel we found in the iMac 5K: LG Display model LM270QQ1. That said, the cabling arrangement and webcam hardware have been moved around—so you can't swap displays between models.
- Repairability Score: 3 out of 10 (10 is easiest to repair). The RAM and CPU are both modular, meaning repairs and upgrades are a go—despite what Apple tells you. The dual SSDs are modular, but custom-made by Apple, complicating replacement. Cutting the tape to open the iMac isn't too hard (with the right tools), but it must be replaced to complete any repair. Key replaceable components are buried behind the logic board, requiring a lot of disassembly for access. The loss of the external RAM access hatch makes for much more challenging upgrades compared with the 27-inch iMac 5K. The GPU is BGA-soldered in place—potentially a major drawback on a "pro" workstation. No easy graphics upgrades are possible, so choose your configuration wisely.

Set Up and Run a Full Bitcoin Node

YOU'LL NEED THIS

BITCOIN CORE

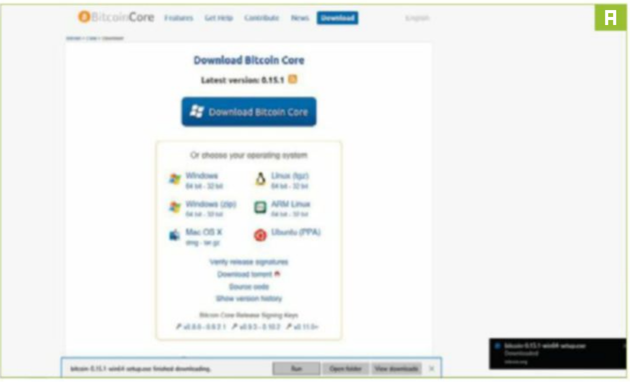
Download the free software from https://bitcoin.org/en/download.

DEDICATED COMPUTER

With an Internet connection.

MOST BITCOIN WALLET SOFTWARE connects to other servers to verify Bitcoins (BTC) you've sent and received. This means that transactions can be linked to your IP address. Lightweight wallets can also be tricked into accepting payments that aren't valid, because they rely on a third-party server for information. The official Bitcoin Core client is a "full" node in that it downloads the entire Bitcoin blockchain, and processes all new transactions on the network—if you're downloading data about all payments received, it's much harder to link them to your identity. Running a full node is also more secure, because it doesn't need to check with a third party that all the rules of Bitcoin are being followed; for instance, if someone tries to spend the same BTC twice.

In this guide, you'll learn how to set up your own full node with the official Bitcoin Core client. To get started, you need enough space to store the blockchain (currently around 155GB), as well as 2GB of RAM. Full nodes also upload and download large amounts of data, so you need a reliable low-cost Internet connection. See https://bitcoin.org/en/full-node#costs-and-warnings for more information. As you'll see, there are ways to reduce both Internet traffic and storage space used. The safest way to run a full node is on a dedicated computer, because there's less risk you'll accidentally download malware. **–NATE DRAKE**



1 DOWNLOAD BITCOIN CORE

Open your web browser and navigate to https://bitcoin.org/en/download. Click "Download Bitcoin Core" [**Image A**]. This should automatically download the correct version of the software for your operating system.

» If you're using Windows 10 with Microsoft Edge, you can choose to automatically launch the installer by clicking "Run." Otherwise, open it from your "Downloads" folder.

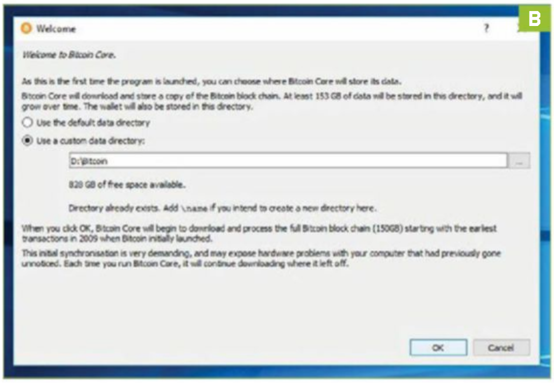
» Once the installer starts, click "Next" to continue. Finally, click "Finish" to complete installation.

» You can now start Bitcoin Core itself. If you're using Windows, you can do this from the Start menu.

2 SYNC BLOCKCHAIN DATA

Once Bitcoin Core launches, the welcome screen asks you to choose a location for your data directory. This is where you'll be storing your Bitcoin wallet, as well as your copy of the Bitcoin blockchain, which currently is around 155GB, so you will need to have plenty of free space.

» Leave "Use the default data directory" checked to use your hard drive to store the data. If there isn't enough space, or you prefer not to store the entire blockchain on your hard drive, click "Use a custom data directory" instead [**Image B**]. From here, you can specify a folder elsewhere, such as on an external hard drive. Click "OK" to start the sync process. This can take anywhere from a few hours to several days.



Welcome to Bitcoin Core.

As this is the first time the program is launched, you can choose where Bitcoin Core will store its data.

Bitcoin Core will download and store a copy of the Bitcoin block chain. At least 153 GB of data will be stored in this directory, and it will grow over time. The wallet will also be stored in this directory.

○ Use the default data directory

● Use a custom data directory:

D:\Bitcoin

820 GB of free space available.

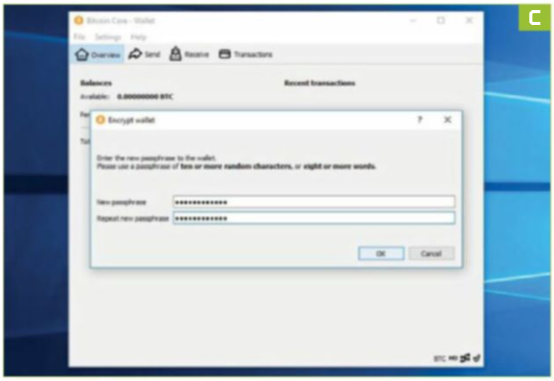
Directory already exists. Add \name if you intend to create a new directory here.

When you click OK, Bitcoin Core will begin to download and process the full Bitcoin block chain (150GB) starting with the earliest transactions in 2009 when Bitcoin initially launched.

This initial synchronisation is very demanding, and may expose hardware problems with your computer that had previously gone unnoticed. Each time you run Bitcoin Core, it will continue downloading where it left off.

3 ENCRYPT YOUR WALLET

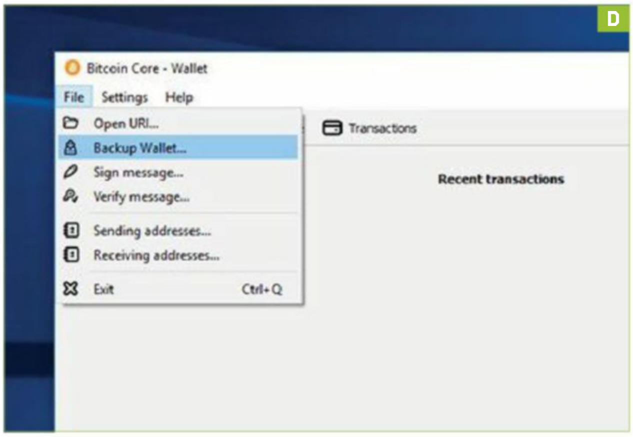
By default, anyone with a copy of the data directory you created earlier can access the "wallet.dat" file and control your Bitcoins. However, you can make life much harder for thieves and hackers by encrypting it. This also gives you something to do while Bitcoin Core



Available: 0.00000000 BTC

Enter the new passphrase to the wallet.
Please use a passphrase of **ten or more random characters**, or **eight or more words.**

New passphrase ••••••••••••
Repeat new passphrase ••••••••••••



is still downloading the blockchain. Click "Hide" for now, then click "Settings → Encrypt wallet." Read the warning message carefully, and choose your password. If you have any dice in your home, consider using Diceware (http://world.std.com/~reinhold/diceware.html) to generate the password.

›› Once you've entered the password, click "OK" [**Image C**]. Follow the advice in the new warning message, make a careful note of your password on a piece of paper, then put it in a safe place.

4

BACK UP YOUR WALLET

As it stands, if your "wallet.dat" file itself becomes corrupted or is accidentally deleted, you would almost certainly lose access to your Bitcoins. So, click "File → Backup wallet" [**Image D**] to export a copy of your wallet file. If you already have a drive you use for backups, place it there. Although your wallet file is now encrypted, try to avoid uploading it to a cloud service, such as Dropbox, because hackers may still try to crack your password. This also makes it easier for others to know you own BTC.

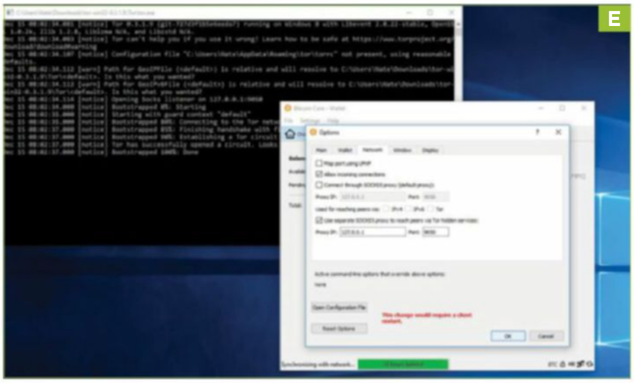
›› If you don't have a dedicated backup drive, copy your "wallet.dat" file on to a USB stick. Remember that anyone who has access to this file and knows your password can control your BTC, so keep it in a safe place.

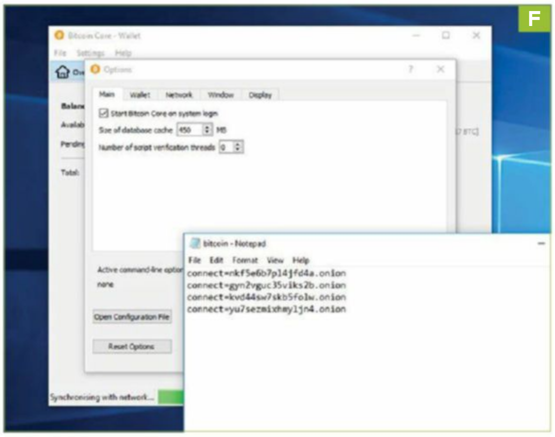
5

DOWNLOAD TOR

By default, anyone with access to your network can see when data is uploaded, making it easy to tell when you're making BTC payments. You can make this much harder to trace by routing Bitcoin Core network traffic through Tor using "onion routing" (www.torproject.org/about/overview.html.en).

›› To get started, visit www.torproject.org/download/download.html.en. Click on "Microsoft Windows," then download the "Expert Bundle." Right-click the file and select "Extract all." Open the new directory, then the one named "Tor." Double-click "tor.exe." If Windows Defender shows an alert, click "More Info," then "Run anyway."





```
connect=nkf5e6b7pl4jfd4a.onion
connect=gyn2vguc35viks2b.onion
connect=kvd44sw7skb5folw.onion
connect=yu7sezmixhmyljn4.onion
```

›› Return to Bitcoin Core. Click "Settings → Options." Choose the "Network" tab, and check the box marked "Use separate SOCKS5 Proxy to reach peers via Tor hidden services" [**Image E**]. Click "OK," then "File → Exit."

›› From now on, Bitcoin Core will connect to peers via Tor. This makes it much more difficult to trace payments, but also massively slows down the time it takes to sync with the network.

6

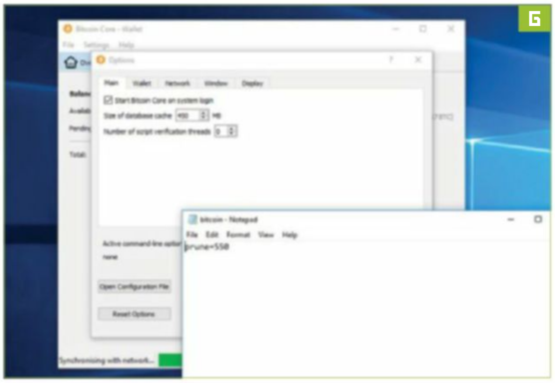
CHOOSE YOUR PEERS

Bitcoin Core has several "DNS seeds" hardcoded into it, which link to IP addresses of other nodes. By default, as soon as you launch the client, it uses the DNS seeds to start connecting with eight other peers to download and verify transaction data.

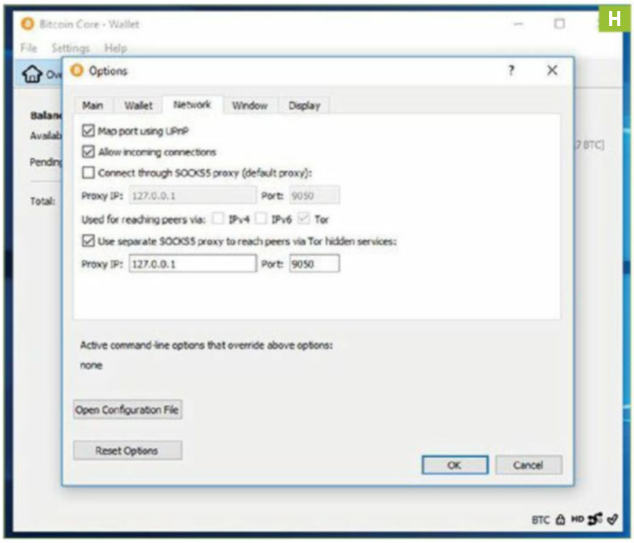
›› If you prefer, you can choose specific peers. This means Bitcoin Core doesn't have to query other servers, making your wallet more private. To get started, visit the Bitcoin Wiki (https://en.bitcoin.it/wiki/Fallback_Nodes) to obtain a list of reliable nodes.

›› Launch Bitcoin Core, and click "Settings → Options." In the Options menu, choose "Open Configuration File." Read the warning message and click "OK." Paste each of your chosen nodes into the empty document on a new line, using "connect="—for example, "connect=173.242.112.53" [**Image F**]. Save and exit. Bitcoin Core will try to connect only to these nodes next time it starts.

›› If you set up connections via Tor in the previous step, you should also consider using the "Tor Nodes" that are listed on the Bitcoin Wiki—for example,



```
prune=550
```



H

☑ Map port using UPnP
☑ Allow incoming connections
☐ Connect through SOCKS5 proxy (default proxy):
Proxy IP: 127.0.0.1 Port: 9050
Used for reaching peers via: ☐ IPv4 ☐ IPv6 ☑ Tor
☑ Use separate SOCKS5 proxy to reach peers via Tor hidden services:
Proxy IP: 127.0.0.1 Port: 9050

Active command-line options that override above options:
none

"connect=gyn2vguc35viks2b.onion." This means Bitcoin Core connects only to other peers in the dark net, making it much more difficult to trace transactions you send and receive. Bear in mind this will slow your download/upload speed.

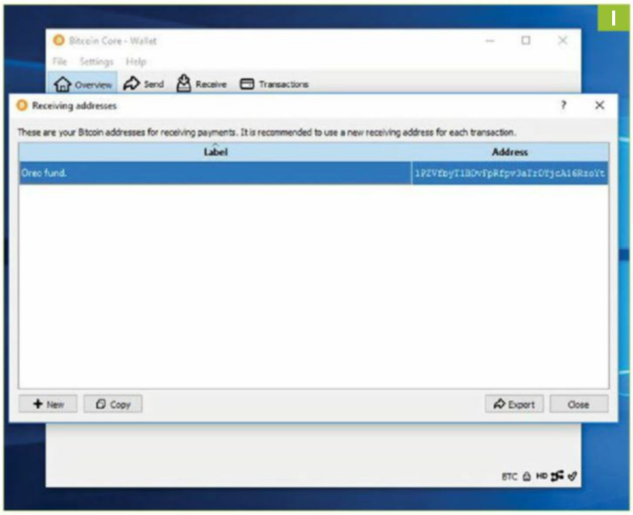
7 ENABLE PRUNING

In simplest terms, "pruning" is the process of removing old blocks of transaction data that have already been processed. In other words, it only stores blocks of data relating to new transactions. You can enable pruning to save space in your Bitcoin data folder (typically, this reduces the space used from around 155GB to 6GB).

» If you can spare the space and bandwidth, try not to use pruning, because it helps newcomers to Bitcoin Core to download the entire blockchain as you did. If you don't have the resources, however, open the Configuration file in the same way as outlined in the previous step, and add "prune=550" on a new line [**Image G**]. Bitcoin Core will remove older transaction data automatically.

8 ENABLE INCOMING CONNECTIONS

As you've learned, when you start Bitcoin Core, it automatically connects to other nodes to download the latest blocks and transactions. If you want to return the favor, and help keep the network honest, you need to configure your router to allow inbound connections on Bitcoin Core's port (8333). The easiest way is from within Bitcoin Core. Choose "Settings → Options," and click the "Network" tab [**Image H**]. Otherwise, you need to manage this yourself via "port forwarding." See the Bitcoin website (https://bitcoin.org/en/full-node#port-forwarding) for help with this.



I

These are your Bitcoin addresses for receiving payments. It is recommended to use a new receiving address for each transaction.

Label: Oreo fund.

» If you're connecting via Tor, Bitcoin Core can automatically create a hidden service, so that other peers can connect to you via the dark net. This makes it harder to tell you're running a Bitcoin node. Follow the Bitcoin instructions for Tor (https://github.com/bitcoin/bitcoin/blob/master/doc/tor.md) to do this.

9 FUND YOUR WALLET

Once Bitcoin Core has fully synched with the network, and you've configured your connection, your wallet is now ready to receive funds.

» In Bitcoin Core, click the "File" menu, then "Receiving Addresses" to list your payment address [**Image I**]. For security reasons, you should use a new one each time you receive payment. For now, copy the one you have, and use it to send any existing BTC to your new wallet.

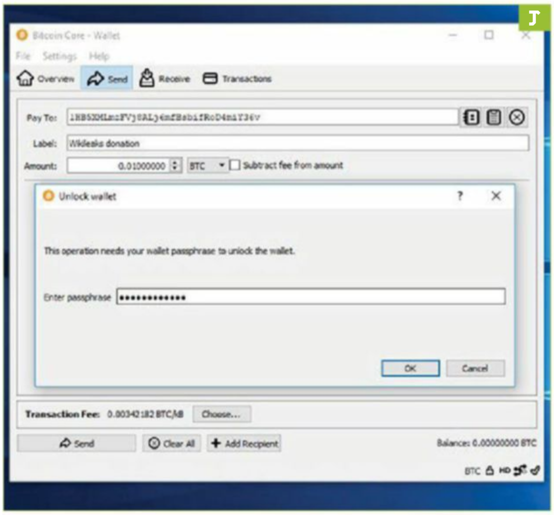
» Double-click the label to set a "Name." You can also click "New" to generate new addresses. Return to the "Overview" tab to check your funds are on the way.

» If you don't have any Bitcoins yet, then you can use an exchange such as Coinbase and Kraken to buy them. We will look at how to do this in a future issue.

10 SPEND YOUR BTC

Click on the "Send" tab when you want to spend your BTC [**Image J**]. The options here are pretty much self-explanatory: Enter your recipient's payment address in the "Pay To" field, optionally set a label, and enter the amount you want to send. You can also use the drop-down menu to switch between BTC and other denominations, such as mBTC (millibitcoins).

» Click "Choose" next to "Transaction fee" to set the amount you're willing to pay to have transaction validated. Generally speaking, the more you're willing to pay, the faster your payment will be confirmed. Select this from the drop-down menu marked "Confirmation Time Target." You can pay just the minimum required fee if you wish, but if the network is very congested, your transaction might never be confirmed. ⏻



J

Label: Wikileaks donation
Amount: 0.01000000 BTC ☐ Subtract fee from amount

This operation needs your wallet passphrase to unlock the wallet.

Enter passphrase •••••••••••••

Transaction Fee: 0.00342182 BTC/kB

Balance: 0.00000000 BTC

XBOX
THE OFFICIAL MAGAZINE

ISSUE 209 JANUARY 2018
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Run Ubuntu Linux Inside Windows

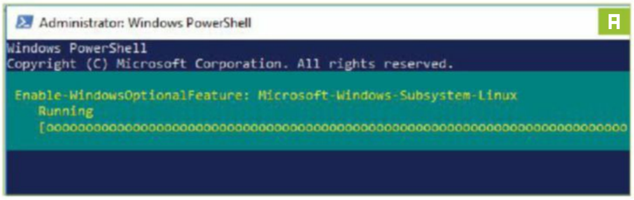
YOU'LL NEED THIS

WINDOWS 10
With the latest Creators Update.

HARDWARE
A 64-bit processor and at least 1GB free on your C drive.

"OH LORDY, NO, NOT THAT LINUX AGAIN!" cries out the rightly indignant *Maximum PC* reader. "Stop trying to foist that beardy, communist-inspired, open-source nonsense on us!" No one wants to install a whole operating system, just to mess around with a bit of terminal-based garbage, so Microsoft did the right thing, and brought Linux inside Windows, using the Windows Subsystem for Linux. Partnering with one of the leading Linux developers, Canonical, it developed the WSL to enable you to effectively install the core of the Ubuntu Linux OS inside of Windows. No mess, no fuss, just pure, simple Windows, with added Linux on top, erm, inside.

"Why?" we hear you despairingly cry. Because developers love it. It enables them to directly install and run common open-source tools, commands, and server services without leaving Windows. It also enables you to monkey around with Linux from the comfort of Windows, without even needing to fire up a virtual machine. So it's free, it's easy to get up and running, won't take up much space, it'll expand your knowledge, and help freak out your friends! What's not to love? Let's give it a try, and explain how you can have some open-source fun along the way. **–NEIL MOHR**



```
Windows PowerShell
Copyright (C) Microsoft Corporation. All rights reserved.

 Enable-WindowsOptionalFeature: Microsoft-Windows-Subsystem-Linux
    Running
    [oooooooooooooooooooooooooooooooooooooooooooooooooooooooooooooooooooooooo
```

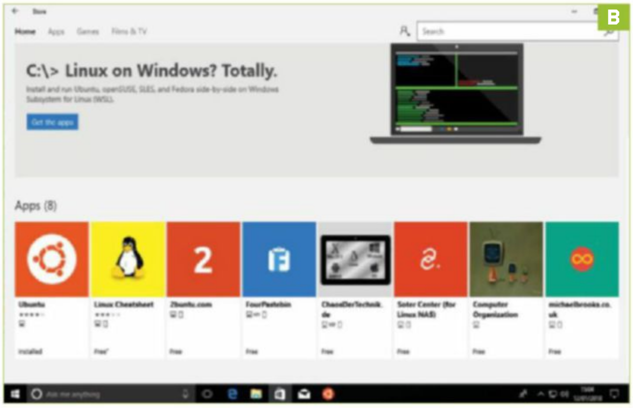
1 PREPARE YOUR PC

Setting up and running the WSL has become somewhat simpler than when it was first introduced back in 2016, as long as your version of Windows 10 has the Fall 2017 Creators Update, which is Windows build 16215, aka Redstone 3. The most complex step is doing the following: In search, type "powershell," right-click this, and select "Run as administrator" [**Image A**]. Enter the following command, and restart your system.

```
Enable-WindowsOptionalFeature -Online -FeatureName
Microsoft-Windows-Subsystem-Linux
```

2 INSTALL LINUX

Head to the Windows Store and search for "Linux." Boom—a whole new section dedicated to Linux on Windows. Will wonders never cease? We're only interested in Ubuntu here—OpenSUSE is another major Linux distro, but it uses a different installer system (known as package management) to Ubuntu. So choose Ubuntu, and click "Get it" [**Image B**]. If you run into an error at this point, ensure you ran the PowerShell command, you have a 64-bit CPU, that you have the correct build of Windows 10, and it's installed on the C: drive under "Default Save Locations" in "Settings."



3 SETTING UP LINUX

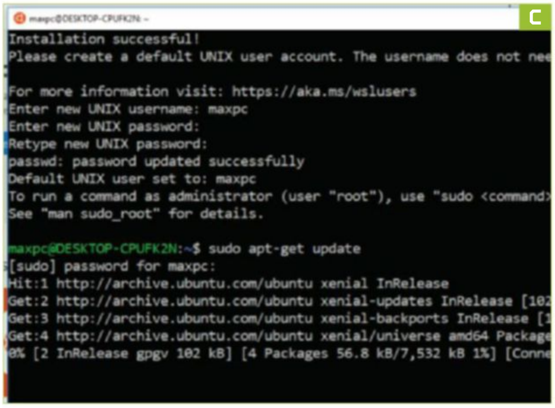
Before you can do anything, you need to create a user account for Ubuntu; enter a suitable username and password. Now begin the obscure terminal incantations to start the Linux magic. These first two ensure Ubuntu has the latest packages, and is up to date, so type:

```
sudo apt-get update
sudo apt-get upgrade
```

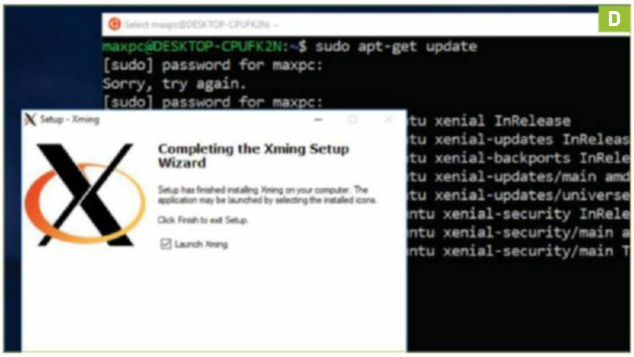
» You'll see a list of scrolling text, which refers to the online repositories where Ubuntu stores OS files, ensuring you have the latest list, then ensuring Ubuntu has them installed [**Image C**]. Typically, it asks you once it's updated them whether it's OK to install the updates.

4 INSTALL A GUI

At this point, all you have is the basic Bash shell—that's the text-based terminal to you, which is super-powerful, but more for developers and server environments, which we're likely not living in or with. The



```
Installation successful!
Please create a default UNIX user account. The username does not nee

For more information visit: https://aka.ms/wslusers
Enter new UNIX username: maxpc
Enter new UNIX password:
Retype new UNIX password:
passwd: password updated successfully
Default UNIX user set to: maxpc
To run a command as administrator (user "root"), use "sudo <command>
See "man sudo_root" for details.

maxpc@DESKTOP-CPUFK2N:~$ sudo apt-get update
[sudo] password for maxpc:
Hit:1 http://archive.ubuntu.com/ubuntu xenial InRelease
Get:2 http://archive.ubuntu.com/ubuntu xenial-updates InRelease [102
Get:3 http://archive.ubuntu.com/ubuntu xenial-backports InRelease [1
Get:4 http://archive.ubuntu.com/ubuntu xenial/universe amd64 Package
0% [2 InRelease gpgv 102 kB] [4 Packages 56.8 kB/7,532 kB 1%] [Conne
```



```
maxpc@DESKTOP-CPUFK2N:~$ sudo apt-get update
[sudo] password for maxpc:
Sorry, try again.
[sudo] password for maxpc:
tu xenial InRelease
tu xenial-updates InReleas
tu xenial-backports InRele
tu xenial-updates/main amd
tu xenial-updates/universe
ntu xenial-security InRele
ntu xenial-security/main a
ntu xenial-security/main T
```

Completing the Xming Setup Wizard

Setup has finished installing Xming on your computer. The application may be launched by selecting the installed icons.

Click Finish to exit Setup.

☑ Launch Xming

cool part is that the Linux world uses a graphical system called X to generate its GUI. X uses a server/client model, which means you can access interfaces over network connections or across subsystems. We'll install a Windows-based X server, and the Linux client will be able to launch GUI-based X tools. Download and install Xming [**Image D**] from https://sourceforge.net/projects/xming/. Allow the firewall exception as well.

5 TWEAK UBUNTU

That's the Windows side taken care of. On the Linux side—you've run Ubuntu, right?—we need to point any GUI activity at the correct display. Type `export DISPLAY=:0.0`.

» To permanently set this display environmental variable, type:

```
echo "export DISPLAY=:0.0" >> ~/.bashrc
```

» That adds the directive to a script that's run each time you start Ubuntu, technically the Bash shell part. Now we need to install a graphical program:

```
sudo apt-get install gedit
```

» This takes a while. Type `gedit` to run the program [**Image E**].

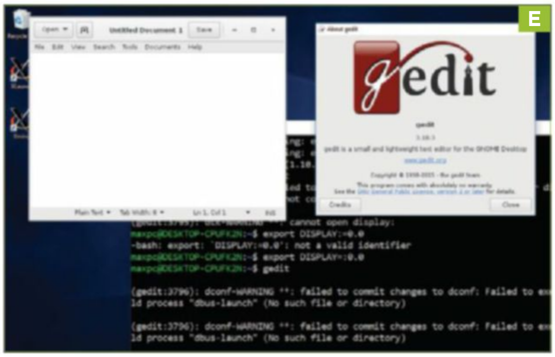
6 INSTALL A DESKTOP

If you research this online, you may find references to Dbus fixes; these are no longer required, because it's now part of the default Ubuntu install. This means we're able to dive in and install a Linux desktop—we're opting for a lightweight one called Xfce4. Run each command here in turn:

```
sudo apt install xfce4
sudo apt install gnome-themes-standard
sudo apt install conky
```

7 PREP YOUR DESKTOP

We're going to do a bit of housekeeping to keep things neat, so run the command `nano ~/.xinitrc` and, in the text editor, enter the lines of code that follow. When done, press Ctrl-o and hit Return to save it, and Ctrl-x to exit the text editor.


E
Open
Untitled Document 1
Save
File Edit View Search Tools Documents Help
Plain Text Tab Width: 8 Ln 1, Col 1 INS
About gedit
gedit
Credits
Close

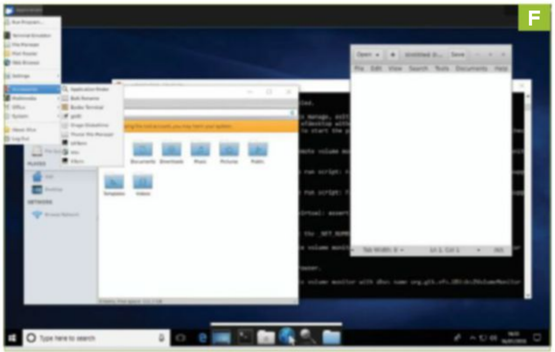
```
maxpc@DESKTOP-CPUFK2N:~$ export DISPLAY:=0.0
-bash: export: `DISPLAY:=0.0': not a valid identifier
maxpc@DESKTOP-CPUFK2N:~$ export DISPLAY=:0.0
maxpc@DESKTOP-CPUFK2N:~$ gedit

(gedit:3796): dconf-WARNING **: failed to commit changes to dconf: Failed to ex
ld process "dbus-launch" (No such file or directory)

(gedit:3796): dconf-WARNING **: failed to commit changes to dconf: Failed to ex
ld process "dbus-launch" (No such file or directory)
```

```
#!/usr/bin/env bash
export LANG="en_US.UTF-8"
export LC_ALL="en_US.UTF-8"
exec startxfce4
```

» Run `chmod +x ~/.xinitrc` to make the file we've just created executable, then use `ln -s ~/.xinitrc ~/.xsession` to "link" that file with another standard X configuration file. Start your newly installed Linux desktop with `dbus-launch --exit-with-session ~/.xsession`.

» On the first run, a dialog pops up—select to use the default. The Xfce4 desktop appears over the Windows 10 one, so you might want to ensure the Ubuntu window isn't full-screen, because the window bar can be blocked. You should spot an "Application" menu top-left, there's a dock at the bottom, with a taskbar running along the top. To quit, use the "Log out" option in the top-left menu [**Image F**].

» You won't find too much to play with at this point, because it's a Linux desktop running on a largely sparse distro. You can add programs, such as Firefox, via `sudo apt-get install firefox` and this then appears under the "Internet" menu. Have fun! ⏻



BEGONE LINUX AND OTHER TRICKS

Previously, removing the WSL was a case of running PowerShell as Administrator, and typing `lxrun /uninstall /full`. Now, if Windows 10 is up to date, all you need to do is remove it from the Start menu/Windows Store. By the time we've finishing installing bits, the Linux install will be pushing 1GB, so it's not something you'll want hanging around your C drive.

We're frankly doing things here with the WSL that it was never designed to do. In fact, trying to get these things working in earlier builds was far more of a bind than they are now. So, if you find you're having a few glitches here and there, it's to be expected.

We're going to leave you here, but there's plenty of other things you can do with the WSL. For instance, running `sudo apt-get install compiz-core` and `sudo apt-get install compizconfig-settings-manager` adds a host of visual effects settings that you can monkey around with. You also might notice there's no sound, and while it is possible to add this, it's rather tricky, and probably not worth your hassle. Long story short: Linux uses a server/client sound system called PulseAudio, and you need to install both a Windows version (tricky), and redirect the output to your host Windows machine. Just for the pleasure of likely hearing out-of-sync sound.

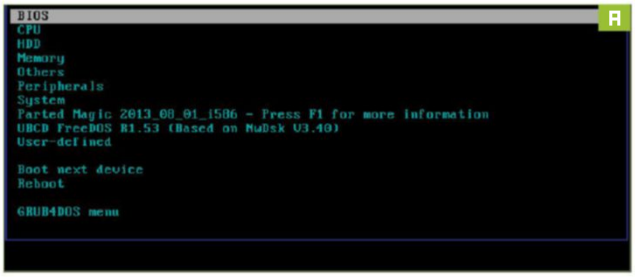
Rescue Old PCs with Ultimate Boot CD

YOU'LL NEED THIS

ULTIMATE BOOT CD 5.3.7
Download the free software from www.ultimatebootcd.com.

USB STICK
This needs a minimum capacity of 1GB.

THERE'S NOTHING WORSE than a machine that seems to have given up the ghost. Windows refuses to boot. Your precious files are locked away. And, without proper diagnostic tools, you can't quite figure out what's wrong with the thing, let alone nurse it back to health. That's where Ultimate Boot CD (henceforth UBCD) comes in. Cobbled together over the course of some 15 years, UBCD is a bootable collection of the best freeware tools for all kinds of rescue tasks. You don't need to run it from a disc—it's happy enough to run from USB if you've long ago cast off the shackles of optical media—and it can do just about anything you need, from cloning or selectively copying from dying drives to checking individual hardware components to determine just what's gone wrong with your ailing hardware. While it's been kept up to date as much as possible, it's worth bearing in mind that many of the tools and drivers in UBCD are geared toward older hardware, so it's best used to bring life to those long-forgotten laptops; if you're resurrecting a more modern Windows 10 machine, try Microsoft's own rescue tools first. –**ALEX COX**



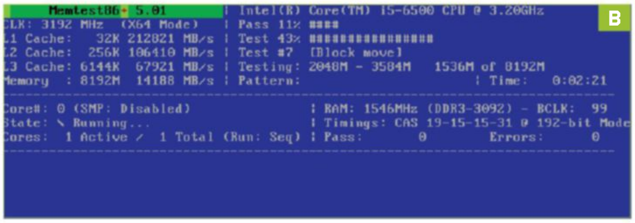
```
BIOS
CPU
HDD
Memory
Others
Peripherals
System
Parted Magic 2013_08_01_i586 - Press F1 for more information
UBCD FreeDOS R1.53 (Based on NwDsk V3.40)
User-defined

Boot next device
Reboot

GRUB4DOS menu
```

1 PREPARE MEDIA

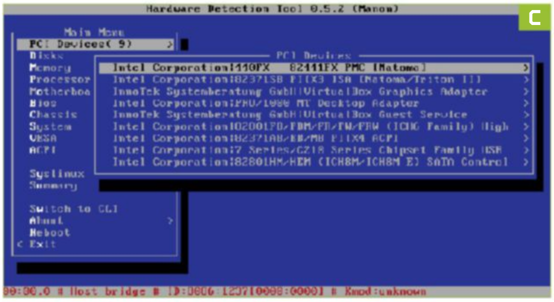
Logical first step time: In order to use the Ultimate Boot CD, you need to be able to boot from it. Use a working computer to grab the UBCD ISO via one of the mirrors on www.ultimatebootcd.com (or use the torrent, if you're feeling conscientious toward the bandwidth bills of volunteers), and find either a USB stick with at least 1GB capacity, or a blank CD or DVD if you're going the optical route. Burn the ISO as you would any other—if you don't have the software, use CDBurnerXP from www.cdburnerxp.se—or write it to USB using Rufus (http://rufus.akeo.ie). Make sure you format your USB media using the appropriate option.

2 BOOT FROM IT

Plug in or insert your media into your target machine, and boot from it either by setting the boot priority in the BIOS, or by invoking its boot media menu. One tiny prerequisite: If your BIOS is somehow hosed, you may not be able to select the appropriate media manually. You could be out of luck if this is the case—although UBCD can help retrieve lost BIOS passwords—but search online for any secret key combinations your hardware manufacturer might have slipped in, because there's often a way to force a USB or optical boot by holding down a modifier on power on.



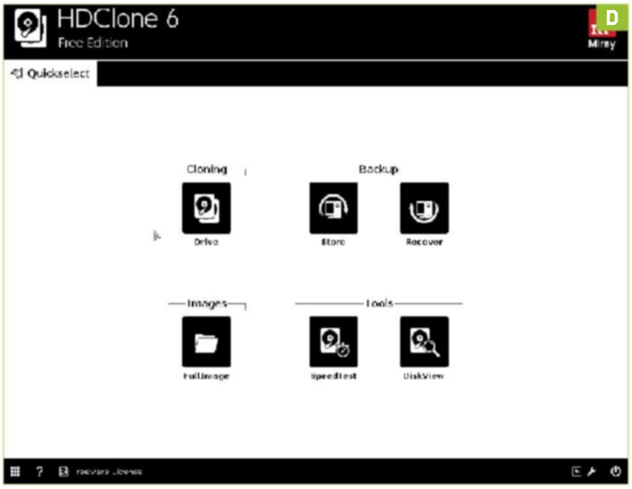
```
     Memtest86+ 5.01       | Intel(R) Core(TM) i5-6500 CPU @ 3.20GHz
CLK: 3192 MHz  (X64 Mode)  | Pass 11% ####
L1 Cache:   32K 212821 MB/s | Test 43% #################
L2 Cache:  256K 106410 MB/s | Test #7  [Block move]
L3 Cache: 6144K  67921 MB/s | Testing: 2048M - 3584M   1536M of 8192M
Memory  : 8192M  14188 MB/s | Pattern:                          | Time:   0:02:21
---------------------------------------------------------------------------------
Core#: 0 (SMP: Disabled)               | RAM: 1546MHz (DDR3-3092) - BCLK:  99
State: \ Running...                    | Timings: CAS 19-15-15-31 @ 192-bit Mode
Cores:  1 Active /  1 Total (Run: Seq) | Pass:        0        Errors:      0
---------------------------------------------------------------------------------
```

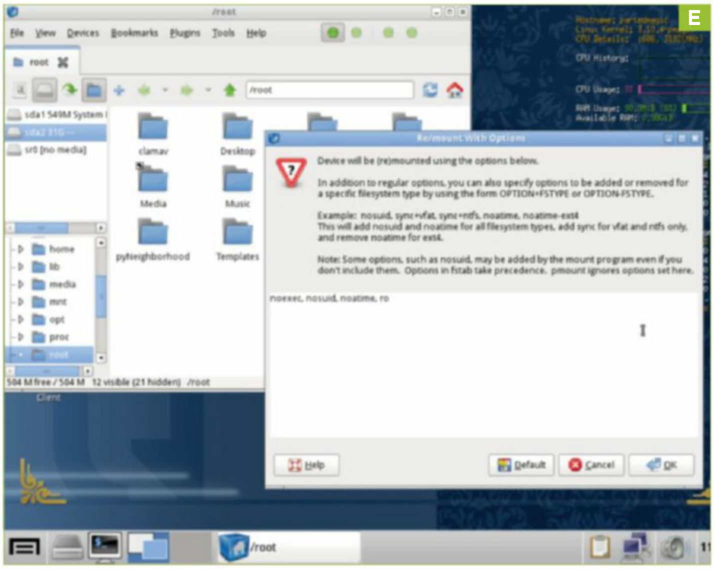


```
                    Hardware Detection Tool 0.5.2 (Manoa)

      Main Menu
 PCI Devices( 9)    >
   Disks            ------------ PCI Devices ---------------------------------
   Memory            Intel Corporation:440FX   82441FX PMC [Natoma]            >
   Processor         Intel Corporation:82371SB PIIX3 ISA [Natoma/Triton II]    >
   Motherboa         InnoTek Systemberatung GmbH:VirtualBox Graphics Adapter   >
   Bios              Intel Corporation:PRO/1000 MT Desktop Adapter             >
   Chassis           InnoTek Systemberatung GmbH:VirtualBox Guest Service      >
   System            Intel Corporation:82801FB/FBM/FR/FW/FRW (ICH6 Family) High >
   VESA              Intel Corporation:82371AB/EB/MB PIIX4 ACPI                 >
   ACPI              Intel Corporation:7 Series/C210 Series Chipset Family USB >
                     Intel Corporation:82801HM/HEM (ICH8M/ICH8M E) SATA Control >
   Syslinux
   Summary

   Switch to CLI
   About            >
   Reboot
 < Exit

00:00.0 # Host bridge # ID:8086:1237[0000:0000] # Kmod:unknown
```

3 CHECK YOUR COMPONENTS

The main UBCD menu [**Image A**] is broken up, usefully, by category. Unless you hear that telltale clicking that means your hard drive is about to breathe its last, it's probably a good idea to give your hardware a quick once-over first of all. The "CPU" menu gives you a chance to test the stability of your processor with a number of stress tests and challenging benchmarks—and if you want a realistic view of your machine's capabilities without the Windows overhead, benchmarking from UBCD is about as close to working on bare metal as you can get. In the




E

Device will be (re)mounted using the options below.

In addition to regular options, you can also specify options to be added or removed for a specific filesystem type by using the form OPTION+FSTYPE or OPTION-FSTYPE.

Example: nosuid, sync+vfat, sync+ntfs, noatime, noatime-ext4
This will add nosuid and noatime for all filesystem types, add sync for vfat and ntfs only, and remove noatime for ext4.

Note: Some options, such as nosuid, may be added by the mount program even if you don't include them. Options in fstab take precedence. pmount ignores options set here.

```
noexec, nosuid, noatime, ro
```

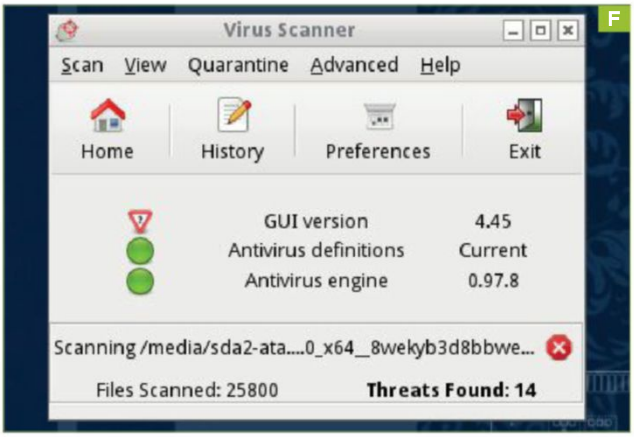
"Memory" section, run the failure-detecting Memtest86+ 5.01 [**Image B**] to comprehensively test every byte of your RAM. And if you don't know what you're working with, a trip to the "System" menu and the Hardware Detection Tool [**Image C**] will reveal all about your system.

4 DRIVE TOOLS

UBCD's area of specialization is its drive tools, and you'll find a whole host in the "HDD" submenu. Problem is, many of these are a little archaic and specific—while there's a long list, it's mostly one collated from drive manufacturers through the ages. Dig around and you may find the right tool for your hardware, either to test it or potentially recover it, and it's worth checking out EaseUS Disk Copy (in "HDD/Disk Cloning") and the slightly-hobbled free version of HDClone (same menu) for their maximum hardware compatibility and graphical interfaces [**Image D**]. But for all UBCD's individual tools, you may be better served going with the expert choice: Parted Magic. The version included with UBCD is the final free edition of Parted Magic—the tool jumped to a paid-for program in 2013—but it's perfectly adequate for backup and recovery purposes.

5 DRIVE ACCESS

Fire up Parted Magic from the main menu—just select the default "Run from RAM" option—and you'll reach a Linux desktop packed with tools. The File Manager should be your first port of call; find your misbehaving hard drive on the left, right-click it, and select "Re/mount." Add the option "ro" to the end of the list [**Image E**] in order to mount the drive as read-only, because presumably we're not here to break anything, and a Windows install that's not playing nice likely won't have shut down properly. You should now be able to dig around in your files; plug in and mount a USB drive, and you'll be able to copy them over.


F

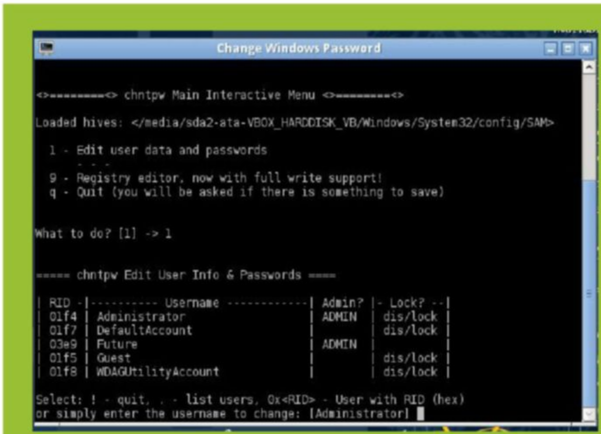
GUI version 4.45
Antivirus definitions Current
Antivirus engine 0.97.8

Scanning /media/sda2-ata....0_x64_8wekyb3d8bbwe...

Files Scanned: 25800 **Threats Found: 14**

6 CLONE AND CLEAN

Linux app Clonezilla is a great tool for swapping out drives—you can, as its name suggests, exactly clone the contents of one drive to another. It's on the Parted Magic desktop as "Disk Cloning." With no drives mounted, fire it up, choose whether you want to back up to an image file or do a bit-to-bit copy of a drive, select "local_dev" on the next screen, plug in your USB drive, and you should be away. Of course, backing up a drive that's failing not because of hardware but because of some insidious infestation is asking for trouble. ClamAV—launched via the "Virus Scanner" shortcut on the Parted Magic desktop—automatically downloads the latest virus definition files and, provided you've mounted your target drive with read/write access (see "Password Panic" below to find out how), it'll attempt to clean up your mucky disk [**Image F**]. Run it before you clone for some peace of mind—or after, if you don't think your platter will last that long.... ⏻



```
<>========<> chntpw Main Interactive Menu <>========<>

Loaded hives: </media/sda2-ata-VBOX_HARDDISK_VB/Windows/System32/config/SAM>

  1 - Edit user data and passwords
      - - -
  9 - Registry editor, now with full write support!
  q - Quit (you will be asked if there is something to save)


What to do? [1] -> 1


===== chntpw Edit User Info & Passwords ====

| RID -|---------- Username ------------| Admin? |- Lock? --|
| 01f4 | Administrator                  | ADMIN  | dis/lock |
| 01f7 | DefaultAccount                 |        | dis/lock |
| 03e9 | Future                         | ADMIN  |          |
| 01f5 | Guest                          |        | dis/lock |
| 01f8 | WDAGUtilityAccount             |        | dis/lock |

Select: ! - quit, . - list users, 0x<RID> - User with RID (hex)
or simply enter the username to change: [Administrator] █
```

PASSWORD PANIC

Forgotten your Windows password? Picked up a new-to-you machine that's locked down? UBCD can help. First, you need to do a little preparation to get Windows out of its default fast boot mode. Just launch Windows as usual, initiate a restart (you don't need to log in), and immediately boot from UBCD—if you try to access it after a full shutdown, you can only use your Windows drive in read-only mode. Launch Parted Magic, mount your drive in File Manager, head to the "System Tools" menu via the app launcher in the bottom-left, and open "Change Windows Password." Select your target hard drive, and use option one to see a list of the installed users. Enter the username you want to change, and use the appropriate options to clear the password, promote the user to administrator, or unlock an account that may have been stifled by over-zealous admin abuse. It's best not to set a new password with this tool—just clear it, log in to Windows, and set a new one from there.

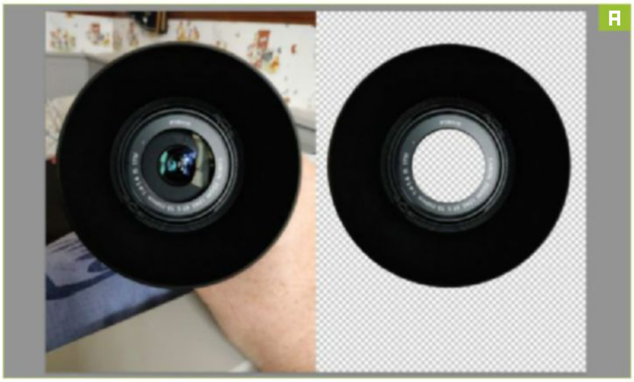
Create an Image with the Droste Effect

YOU'LL NEED THIS

PHOTOSHOP OR GIMP
Various Photoshop subscriptions available from www.adobe.com, or grab Gimp for free from www.gimp.org.

YOU'VE SEEN THE DROSTE EFFECT MANY TIMES, probably without knowing what it's called. That's OK, we didn't know it was named after an obscure Dutch chocolate company that used it in its advertising either, but now we do. The effect is a recursive one—a picture within a picture within a picture, getting smaller each time. A bit like standing between two mirrors and watching yourself endlessly repeated to infinity. Or at least until the image is so small it can no longer be recognized.

There are two main types of Droste image. The simplest repeats an image in something like a photo frame or painting on a wall, while a more complex variant traces a line between the recursive images for a vortex-like result. There was once a Photoshop plugin named Pixel Bender that made the creation of these images easy, but it was never updated to work past the CS5 release. However, there is another image-editing app, one whose name is rarely spoken: Gimp. It's free, so go to www.gimp.org, install it, then come with us down a path less well trodden. **–IAN EVENDEN**



1 FIND A PHOTO

We're actually going to start in Photoshop, because we know it really well, only using Gimp for the final transformation, but you can do everything in Gimp if you're confident. It works best with a photo of something circular, so go out and find a storm drain outlet, a train tunnel, a barbecue smoker, a flower, that sort of thing. We used the end of a camera lens for our shot. You can do this with someone's face, if you photograph them with their mouth wide open, or maybe with a great big close-up of their eye, but be prepared for a horrifying result. Once you've got an image you're confident can be twisted into a recursive helix, open it in Photoshop, and set about removing not only the background outside the circular part, but the inside, too [**Image A**].

2 TURN ON TRANSPARENCY

To get the transparency, double-click your background layer in the Layers palette, renaming it to something like "Layer 0," then create a new layer, and place it behind Layer 0. When you've made your selection, hit "Edit → Clear," and a transparent hole appears, rather than filling it with the background color, as would have happened if we hadn't added the layer. Don't flatten the layers. Save your newly cut-out image as a TIFF, ensuring you check the "Save Transparency" box on the TIFF options window.

3 INSTALL MATHMAP PLUGIN

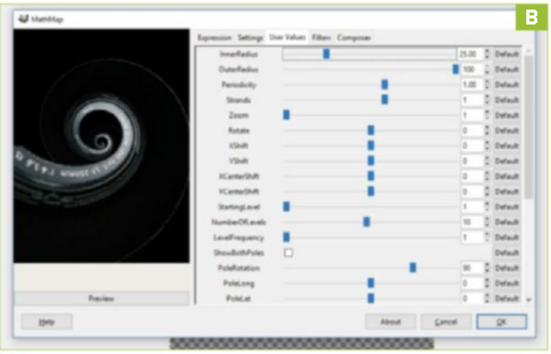
To get the Droste effect, you need a plugin. The one you want is called Mathmap, and it's on the Gimp Plugin Registry. Google is your friend. Once you've got it installed, there's another hurdle to jump—the plugin needs to be told what to do. There's an 11-year-old discussion thread on Flickr by software engineer Josh Sommers, in which he posts precisely what you need: a complete Droste effect Mathmap recipe to copy and paste. Here's the link: http://bit.ly/2CSzvFb. And maybe find a way to thank the man for his work, too.

4 PASTE IN CODE

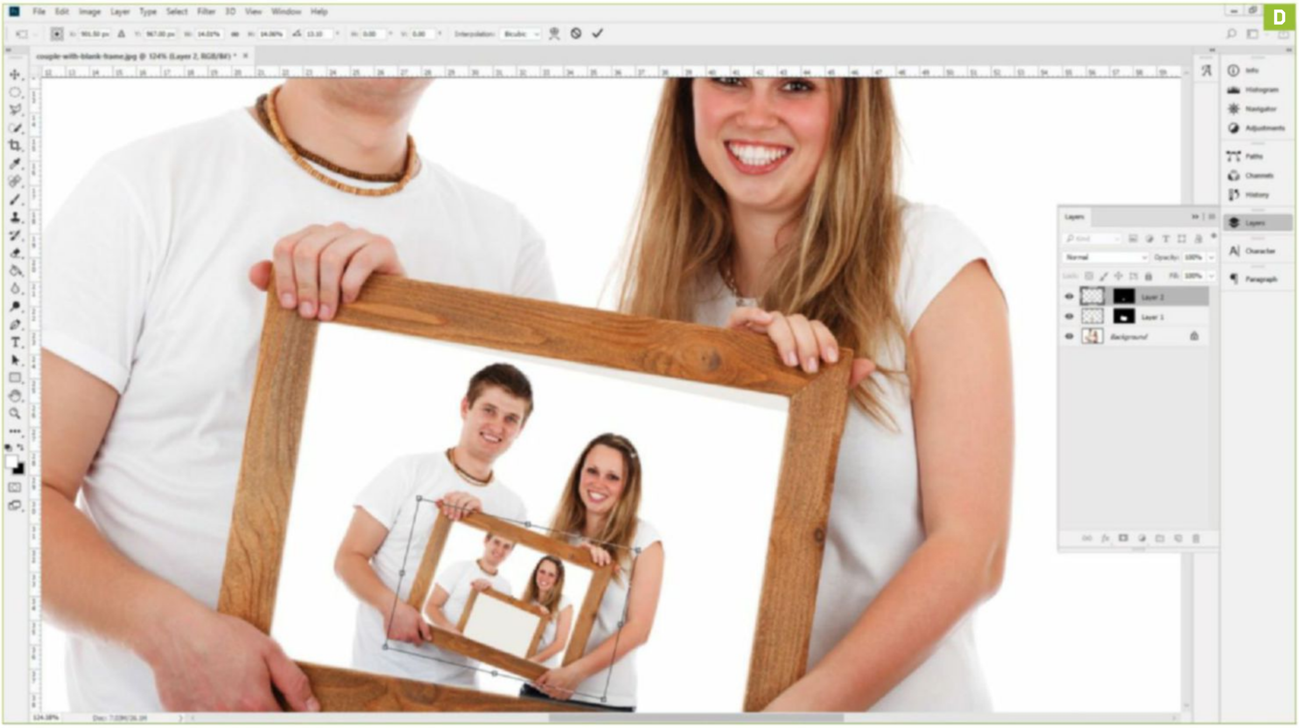
Copy the recipe—it's huge—then open Gimp and your image. Head to "Filters → Generic → Mathmap → Mathmap," and paste the code into the Expression window that opens, making sure you completely replace anything that's already there. Immediately save the new filter, so you don't have to paste it in again, then hit "Preview." This gives you an idea of the end result with the default settings.

5 EXPERIMENT WITH VALUES

We're not going to leave the settings at their defaults, though. Move to the "User Values" tab [**Image B**], and play with the sliders, noting the effect they have on the preview window. You'll always have a flat edge somewhere on your image, so it's worth adjusting the "Inner" and "Outer Radius" settings, so that this intersects with the edge of the image area, making it look as if the image continues outside the frame, rather than having a sudden flat cut-off. "Periodicity" affects how tightly wound your spiral is, and can undo the work you've done with the radius, meaning you have to go back and fix it. "Strands" changes the



InnerRadius 25.00
OuterRadius 100
Periodicity 1.00
Strands 1
Zoom 1
Rotate 0
XShift 0
YShift 0
XCenterShift 0
YCenterShift 0
StartingLevel 1
NumberOfLevels 10
LevelFrequency 1
ShowBothPoles ☐
PoleRotation 90
PoleLong 0
PoleLat 0


D
File Edit Image Layer Type Select Filter 3D View Window Help
Layers
Layer 2
Layer 1
Background

number of spirals created, making the problem of keeping the edges lined up with the sides of the image more complicated [**Image C**].

6

MORE OPTIONS

The next slider is "Zoom," and you can use this to cut off any flat ends, as well improve the composition of your helix. "Rotate" does what you'd expect, while "X" and "Y Shift" move your composition against the background. "XCenter" and "YCenter Shift" are more interesting, adding a 3D-like perspective shift. The other options have very specific uses, and don't bring much to an image if you're looking for a simple recursive spiral. The exception is "HyperDroste," which adds a cool fractal effect you may like.

7

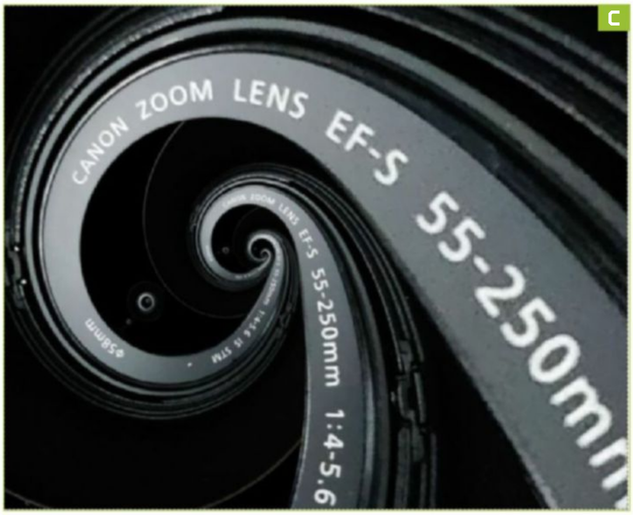
FINAL TWEAKS

We went back to "Settings" to mess with the "Edge Behavior" buttons before hitting "OK," as they add background interest. On a 20MP starting image, it can take a while to process the effect—using a Core i7 overclocked to 4.1GHz, we still had plenty of time to check Twitter while it was chewing through data. And there you have it, a recursive helical Droste effect.

8

ALTERNATE STYLE

For the simpler type of Droste image, in which a picture appears multiple times inside itself, choose an image with a rectangular frame or window in it, then copy the entire image before selecting the inside of the frame or window. Use "Edit → Paste Special → Paste Into" to make the image appear inside the selection, shrinking it down and rotating with "Edit → Free Transform" [**Image D**] as necessary. Doing this creates lots of new layers with masks on them, so you need to flatten the image before exporting it. The resolution of your image dictates how far you can go; shrinking the image each time eventually turns it into an unrecognizable blur. ⏻



NOTHING NEW UNDER THE SUN

Famous uses of the Droste effect, outside of chocolate marketing, include MC Escher, whose 1956 lithograph *Print Gallery* shows a gallery including a print that depicts the gallery that includes the print… and so on, until it reaches a central void. British psychedelic guitar noodlers Pink Floyd used it on the cover of their 1969 album *Ummagumma,* changing the repeated image slightly each time so that band members appear to change position. And as far back as 1320, Italian painter Giotto, who would later give his name to a space probe investigating comets, painted a triptych to serve as an altarpiece for one of the altars of Old St Peter's Basilica in Rome. This depicts the cardinal who commissioned the piece offering the triptych itself to St Peter.

BUILD IT

ZAK STOREY, DEPUTY EDITOR

QHD Gaming

ITX, Ryzen, and a GTX 1070 Ti, all packaged into a lovable little bundle

LENGTH OF TIME: **2-3 HOURS**

LEVEL OF DIFFICULTY: **HARD**

THE CONCEPT

RIGHT, let's break this down quickly, and cover off the pain we suffered building it. In short, we forgot just how much hard work is involved when constructing a rig like this inside such a small case. There's a certain amount of anguish and scraped knuckles that goes along with building the miniature inside the tiny. And it's an accepted fact that it's going to hurt. Yet, despite this, ITX builds will always have an allure, an attractive enticement to any would-be PC enthusiast.

Why put yourself through so much torment—with cramped build conditions, frustration, and more—to construct a system that would be just as at home in a mid-tower, as it would here? Well, two reasons. Firstly, there's something intensely appealing about packing huge levels of performance inside a small enclosure. And secondly, we love a challenge. And that's exactly what the BitFenix Portal provides. That notion of saying to your buddies, "Yeah, I built this awesome rig, in that tiny case, and it performs incredibly." The potential pride is difficult to ignore.

The Portal, with its otherworldly design, is an intriguing case. Much like the Prodigy that came before it, the enticing lines and intricate styling almost entrance you, willing you into wanting to work it into something masterful. But it's a trap. Much like the sirens' song or Pandora's box, once your curiosity has been aroused, there's no going back. No return from the torment of this hell you've dragged yourself into. For the next however many years, it'll be both your beauty and your burden. And there's a quality in that, that's hard to come by in life.

OK, THIS ISN'T FUNNY ANYMORE

ONCE UPON A TIME, this would have been a mid-range build. Can you believe that? If we take the RRP of the GTX 1070 Ti, and the price for a 16GB kit of 2,666 memory from way back in our Holiday 2016 issue, you'd currently be looking at a rig that would cost about $1,660. At the upper end of mid-range, we'd argue. Not cheap, but pretty damn impressive. For that cash, you'd get yourself a machine that could hammer away at games at 1440p with ease, and dominate any rendering task you could throw its way. So, ignoring the current crazy pricing, let's talk specs for a bit, and pretend everything's fine. We mean, it is, right? Guys? Right?

We knew from the get-go that space was going to be a privilege in this build, so for storage, we decided that anything beyond 2.5 inches in size just wasn't going to work for us, regardless of what the Portal supports. We're still itching to get our hands on one of Seagate's 2.5-inch 2TB old-school hard drives with spinning platters, but Crucial's latest MX500 is a super-cheap, reliable 500GB SSD option that we can pop in here without worry.

The one thing that caught us out was the lack of support for ATX power supplies. Our first build attempt with the Portal was a failure because we didn't realize this, and tried to fit the thing with a Corsair RM PSU. So, to solve our mistake, we decided to grab one of Be Quiet!'s super-cute (no, seriously, they're adorable) SFX-L 600W modular PSUs. How the hell Be Quiet! managed to cram so much hardware into such a confined space is a mystery to us, but it's one brute of a small form factor PSU, capable of powering some gnarly rigs.

Speaking of Be Quiet!, we also decided to opt for its Dark Rock TF low-profile cooler. It's a tight squeeze, but the additional downward cooling should help alleviate Ryzen's brutish thermals, especially in the Portal, which is hardly brimming with intake airflow opportunities.

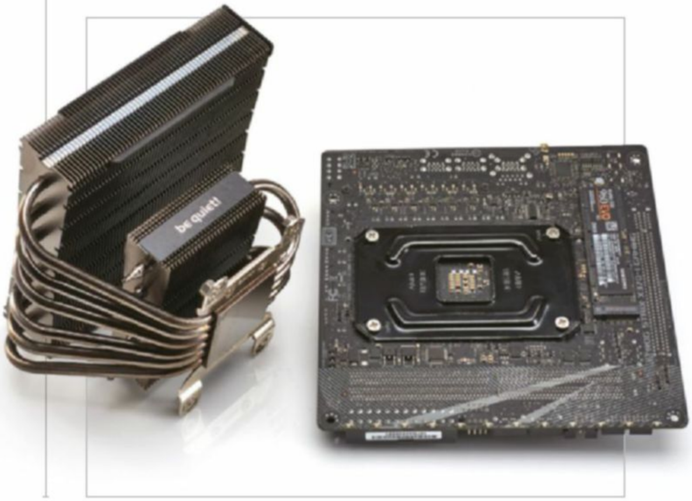
INGREDIENTS

PART		STREET PRICE
Case	BitFenix Portal—Black	$100
Motherboard	Asus ROG Strix X370-I Gaming	$190
CPU	Ryzen 5 1600	$200
Memory	16GB (2x 8GB) Corsair Vengeance LPX 2,666	$197
GPU	Asus GeForce GTX 1070 Ti ROG Strix 8GB	$1,000
PSU	600W Be Quiet! SFX-L	$120
Storage 1	250GB Samsung 960 Evo PCIe M.2	$119
Storage 2	500GB Crucial MX500 2.5-inch	$135
Cooling	Be Quiet! Dark Rock TF Low Profile Cooler	$78
OS	Windows 10 Home	$100
Total		$2,239

1

BESPOKE BACKPLATES

BE QUIET! HAS never been known for its intuitively designed mounting mechanisms. Usually a pain to get to inside a chassis, we knew in advance that it was probably a smarter move to work with this one externally. Basically, you mount the backplate, push through four screws, clip them down on the other side, attach the mounting bracket to the cooler, then turn the cooler upside down, place the motherboard on to the cooler, and secure from the backplate, using a screwdriver. It's neat, if not a bit frustrating.



2

FITTING FRUSTRATION

AND WELCOME to our first frustrating moment. In short, on first install, with the world's tightest fan clips, the motherboard simply wouldn't fit inside the chassis pod with the top fan installed on the CPU heatsink. Solution? Painstakingly remove the tight-as-hell fan clips from the top fan, pull it out (making sure to keep the fan plugged into the board), insert the motherboard, secure it down in place with screws, then slide the fan back in, carefully reclipping it back on to the heatsink, slicing your finger open at the same time. Win!

3 PSU PROBLEMS

EXCEPT, you don't do that. What you do is install the modular PSU first. Otherwise, you can't fit the PSU in after the motherboard is installed. And you'll have to repeat the whole process again. Twice. So, remove the two 3.5-inch hard drive cages from the front caddy, slide the PSU into place—fan facing down for maximum airflow—secure it with a selection of screws, then install the motherboard.

4 GRAPHICS GRUNT

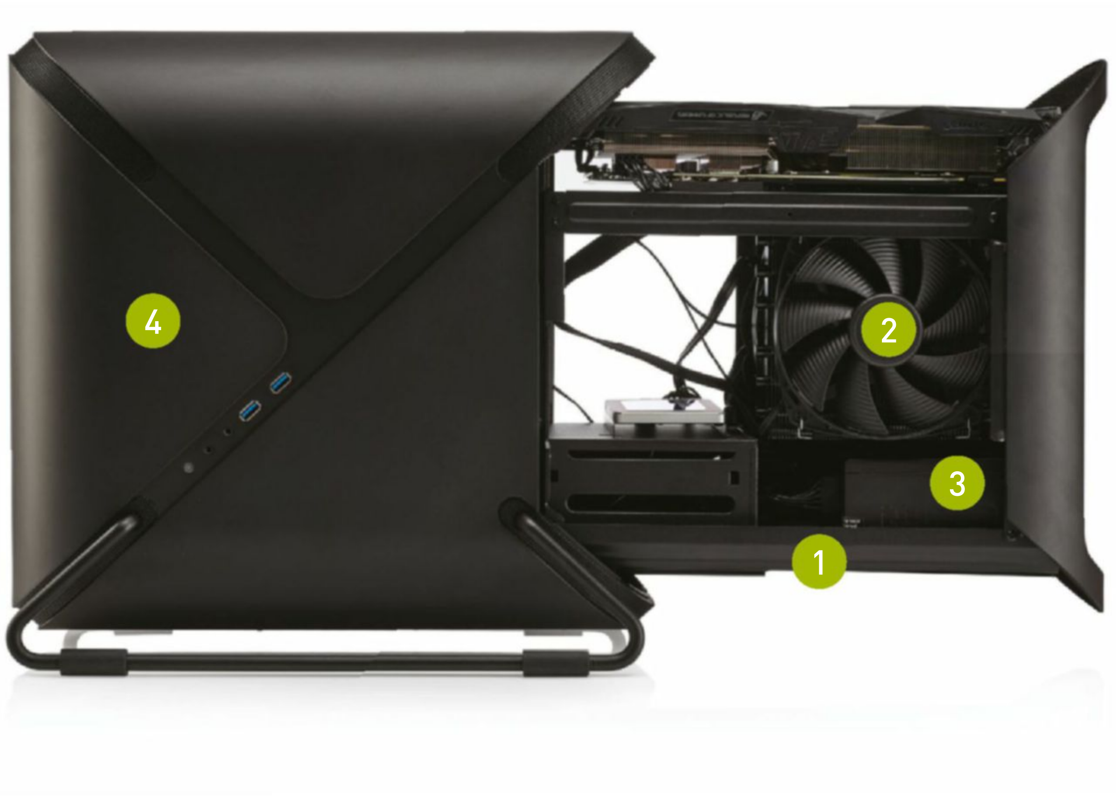
ONCE THAT'S DONE, it's time to carefully start threading those PSU cables through the front bay, and connecting them to the motherboard. Make sure to leave one PCIe cable power out for the swanky GPU you'll be putting in next. To install this, remove the PCIe bracket guard on the back, take off the two covers, carefully line your GPU up with the PCIe slot, then, with a bit of effort and care, force it into place. You'll have to do this, because the two metal feet sticking out the bottom of the I/O plate on the back of the GPU have to slot into the extremely narrow and annoyingly positioned cutouts in the caddy itself, making it notoriously difficult to line up carefully.

5 CONNECTOR CONUNDRUMS

OK, SO NOW we're getting to the end, surely it's not that bad? Think again! Front panel connectors—oh yes. Take a quick look at step 6, and you'll see just how tight a space you have to work with. Honestly, we recommend you skip the HD audio pass-through; you can remove it from the front I/O in the case, simply by pulling on the cable from the inside. It's not super-easy to install later if you do need it, but it's a connector that simply plugs in, so no worries. Then, once that's out the way, carefully install the cables to the front I/O headers on the motherboard.

6 FINALLY FINISHED

AND, AT LAST, the fun bit. Now you're all finished, you'll want to pick up your case pod, and carefully align the two notches on the bottom with the two holes on the sliding rail. Then, carefully slide the pod back inside the chassis, making sure that you don't catch any of the cables on any of the fans littering the insides. Once that's all done, you're good to go. Power on, and hope that nothing's going to catch those fans.



1 This image is for decorative purposes only—never leave the fully equipped caddy extended on the sliding rail like this. You'll damage it.

2 Be Quiet!'s low-profile cooler is a godsend for this build. Its immense TDP leveraging potential keeps everything cool in a compact space.

3 600W of juice from a small form factor PSU? Madness. You could run a Core i7-7900X, GTX 1080, 32GB of DDR4, and 1TB plus 250GB M.2, and still have 200W spare.

4 You've gotta give BitFenix points for style—the Portal is simply stunning.

BEAUTIFUL BUT DEADLY

WHEN ALL'S SAID AND DONE, this system is the purest form of awesome. No, seriously—despite how difficult it was to work with, despite the many cuts and bruises we suffered while building, benchmarking, and diagnosing its predicaments, it has to be one of the nicest small form factor systems we've ever pieced together. Pictures really don't do it justice. It's only once you get inside and realize how tight everything is that its true genius comes to light.

It is equal to the sirens: deadly, but oh so beautiful. That said, there's a lot here that BitFenix could improve upon. Finding a way to install that power supply from the rear, for instance. Mounting the hard drive caddy so it's midway up the case pod, giving you room for cable management at the bottom. Bigger holes to allow an easier fit for those titanic GPUs. Better front fan intakes. And even some smarter cable management for that front I/O would have made this thing a dream.

It's difficult to design a chassis at this form factor, and the Portal is nothing if not exceptional in design. It's just lacking a few quality of life changes that would make it much easier to work in.

As for performance? Well, that's a mixed bag, too. Stepping outside of pricing for a moment, it's incredible. Stomping games at 1440p makes one happy gamer, and having the grunt to render video on the sidelines, too? Well, it can do anything. The SSD storage is exceptionally quick as well—load times feel almost instantaneous in places.

We did have trouble with that Samsung 960 Evo, though, with it seemingly having died since its last build, meaning another strip-down, and replacement with a spare. That aside, storage is as quick as you would expect from a budget PCIe drive from Sammy.

But now we do have to talk about the price, and it's a tough one to swallow—$550 over the recommended retail price for a GTX 1070 Ti, and a painful $130 more on memory. It's not a good feeling. On Ryzen's launch, that could have easily netted you double the memory, an eight-core Ryzen 7 1800X, and a GTX 1080 on top for the same price. However, unfortunately, we no longer live in that world, and until Samsung, Micron, SK Hynix, and every other semi-conductor company get their assets together, it's one annoyance we'll have to endure for the time being. ⏻

BENCHMARKS

	ZERO-POINT	
Cinebench R15 Multi (Index)	959	1,143 (19%)
CrystalDisk QD32 Sequential Read (MB/s)	1,721	1,688 (-2%)
CrystalDisk QD32 Sequential Write (MB/s)	1,473	1,430 (-3%)
Rise of the Tomb Raider (Avg fps)	93	81 (-13%)
Total War: Warhammer II (Avg fps)	55	53 (-4%)
Tom Clancy's Ghost Recon Wildlands (Avg fps)	48	43 (-10%)
3DMark: Fire Strike (Index)	9,128	8,817 (-3%)

0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%

Our zero-point consists of an Intel Core i5-8400, 16GB of Corsair Vengeance LPX 2666, an MSI GeForce GTX 1080 Armor, and a 500GB Samsung 960 Evo PCIe SSD.

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REVIEWS

TESTED. REVIEWED. VERDICTIZED.

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Falcon Northwest Tiki

Bow down to this awesome totem of power

FALCON NORTHWEST (henceforth Falcon) knows a thing or two about building extremely high-end custom PCs. It's been doing that for 26 years now, and while you can certainly pick up a super-sized Mach V with all the trimmings, for us the Tiki is where it's at. It measures just 4 x 13.5 x 13.25 inches, and uses a Mini-ITX Asus motherboard, with a custom chassis that you can't buy anywhere else in the world. The small size is great, but seeing just how much power gets packed inside is what will really turn heads.

Starting at the top, there's the CPU. Falcon sent this rig in with a Core i7-8700K overclocked to 5.0GHz—no mean feat, though we did see some slight throttling to 4.9GHz in a few CPU-intensive workloads. If you'd like something with beefier core counts, Ryzen 7 is another option, or you can go whole hog with up to an 18-core i9-7980XE, or step down to a slightly less insane 12-core i9-7920X. Falcon doesn't generally recommend overclocking the Skylake-X parts in the Tiki, however, because the power draw can be quite high. But if you really want it, Falcon can work to make it, though you still won't come close to the 5.0GHz clocks of the 8700K.

The real star of the show for this Tiki isn't the CPU, though, it's the hot new Nvidia Titan V, decked out in gold, just in case you wasn't aware that this is a $3,000 graphics card, of course. Nominally, the GPU is for entry-level machine learning and AI research, but it's also the first Volta-based card that you can put in a standard desktop. With 5,280 CUDA cores, plus 12GB of HBM2 memory, it's easily the fastest graphics card around right now. Yet not at all practical—but then, with its slick custom paint jobs, Falcon is hardly known for practicality.

The Titan V is crazy fast, beating a 1080 Ti by 13 percent on average across an extensive gaming suite at 4K maximum quality. But that's running at stock, and Falcon will overclock your graphics card as well. The GV100 at stock often hovers at close to its base 1.2GHz clock speed, thanks to power and thermal limits. Increase the power budget and fan speeds, though, and tack on a 100MHz GPU core overclock, and you'll see speeds closer to 1.6GHz (with short-lived peaks as high as 1.9GHz—it seems the GPU can't sustain those clocks without drawing too much power, however).

The HBM2 also managed a healthy overclock of 200MHz, which might not seem like much—until you realize the base clock is only 850MHz. That's a 24 percent overclock on the memory, with a 25–33 percent overclock on the GPU core, and the result is gaming performance that's on average 25 percent higher than stock.

If you want to do some AI research, Nvidia's benchmarks show the Titan V outperforming the Titan Xp by a whopping 154 percent in Resnet-50 training, a deep learning image recognition suite. That's thanks to the Tensor cores, which can crank out an impressive 110 Tflops (stock) of FP16 calculations—it makes the 25 Tflops of FP32 performance on the Titan Xp look tame by comparison.

The A-list of hardware doesn't stop with the CPU and GPU, however. For storage duties, Falcon equipped the Tiki with not one but two Samsung 960 Pro 2TB M.2 SSDs, running in RAID 0. The drives are so fast that the DMI 3.0 interface with the chipset becomes a bottleneck on the Z370 motherboard, but with over 3,000MB/s of sustained reads and writes, we don't think anyone will be complaining.

The Tiki is the fastest PC we've seen in a while, for gaming and other purposes. It runs quiet, thanks to liquid cooling on the CPU, which is particularly impressive, considering the compact size of the case. It's also one of the most expensive desktops we've ever used, but sometimes you have to pay to play. Falcon can put together a far more reasonably priced build, however, with the base Tiki starting at less than $2,500, and that still includes an overclocked six-core i5-8600K, 16GB RAM, and a 512GB M.2 SSD. **–JARRED WALTON**

BENCHMARKS

	ZERO-POINT	
Cinebench R15 Multi (Index)	2,178	1,652 (-24%)
CrystalDiskMark QD32 Sequential Read (MB/s)	3,136	3,532 (13%)
CrystalDiskMark QD32 Sequential Write (MB/s)	2,126	3,093 (45%)
Rise of the Tomb Raider (fps)	68	91 (34%)
Total War: Warhammer II (fps)	42	63 (50%)
Ghost Recon: Wildlands (fps)	38	46 (21%)
3DMark: Fire Strike Ultra (Index)	6,988	8,733 (25%)

0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%

Our 4K system zero-point consists of an Intel Core i9-7900X, an MSI GTX 1080 Ti Gaming X, 32GB of DDR4-3000, and a 512GB Samsung 960 Pro (roughly $3,400). All games tested at 4K at the highest graphical profile.

VERDICT 9 KICK ASS!

Falcon Northwest Tiki Titan V

+ **TIKI** Insane performance; tiny size; runs quiet.

− **CHEEKY** Insane price; size constraints.

$9,740, www.falcon-nw.com

SPECIFICATIONS

Processor	Intel Core i7-8700K @ 5.0GHz
Graphics	Nvidia Titan V
RAM	32GB (2x 16GB) G.Skill Ripjaws V DDR4—3,000MHz
Motherboard	Asus ROG Strix X370-I Gaming
Primary Storage	4TB (2x 2TB) Samsung 960 Pro PCIe SSD RAID 0
Cooling Solution	Asetek Liquid Cooling 550LC AIO
PSU	650W Silverstone SX-650G 80+ Gold
Case	Falcon Northwest Tiki Windowed + Exotix Clouds Paintwork
Warranty	Three-year parts and labor

The Tiki packs more power per cubic inch than any other system we've seen.

Lenovo Explorer

A fresh look at VR—with help from Microsoft

VIRTUAL REALITY hasn't been the hit many expected. Almost two years after the release of the Vive and Rift, the PC finds itself playing second fiddle to the Sony PlayStation VR. The console upstart accounts for 49 percent of the VR market, with 21 percent going to the Rift, and 16 percent to the room-scale HTC Vive. The last 14 percent is claimed by largely wire-free options, which many expect to represent the future of the tech.

Into this fragmented landscape, the Lenovo Explorer and the rest of the new Mixed Reality headsets find themselves as something of an evolutionary oddity, straddling the moves made by the first-gen headsets and the untethered second-gen models. The hardware spec for the Lenovo Explorer puts in a good show against those first headsets, supporting a higher native resolution, and the option of augmenting the real with the virtual, but it still relies on a long cable plugged into your graphics card, anchoring you to the real world.

The most important aspect for any VR headset is the quality of the image that hits your eyeballs, and here the Explorer is a mixed bag. The screen door effect that was evident on the first generation models is still there, but not as obvious, and the added clarity of the higher resolution 1440x1440 displays is welcome. We did have a problem with focus, though, and found getting the image perfect in both eyes at the same time almost impossible.

At 13oz, the headset is light and comfortable in use, but the foam cushioning around the visor introduces subtle movements when you move your head, which causes blurring of the image. The immersion isn't ideal either, because the screens are small, which gives a

An improvement on first-gen VR, but it doesn't go far enough.

general feeling that you're experiencing these virtual worlds through a diving mask, rather than actually being in the world. There are headsets that try to improve the field of view (FOV) problem, and using the Explorer, we can see why the industry is eyeing up such a move.

Like the first-generation headsets, the Lenovo Explorer lacks audio playback, preferring to let the user use their own headphones of choice. An argument we can understand in theory, but in practice it means there are even more wires and clutter to hit that immersive experience. The fact that the just-announced Vive Pro integrates audio into the headset is a good sign of where things need to go.

You're going to need a relatively kick-ass machine to get the most from this headset—it shouldn't come as too much of a surprise to learn that you'll need a modern graphics card, although the reliance on Bluetooth 4.0 indicates that this is a platform that is aimed at laptop users more than high-end desktops. If your motherboard doesn't have Bluetooth, you can pick up a dongle cheaply enough (you can find plenty on Amazon for less than $10), which does have us wondering why this isn't just included in the pack.

The controllers themselves work well, and feel good in hand. And while, initially, knowing where the various buttons and thumbsticks are is a little tricky (you can't see them, after all), a couple of hours in, it's all very natural. The Lenovo Explorer supports room-scale VR without relying on Lighthouses, too, and from our experience, it works well, although you do need a good square yard or so of space to use it properly. Alternatively, you can just use it on your desk.

There is another, potentially bigger, problem for Lenovo, though—nearly two years after the release of the original HTC Vive and Oculus Rift, there's still no killer app. There simply isn't a convincing reason to buy into VR. Windows Mixed Reality does scatter a few more apps into the mix, but there's nothing meaty enough to have us recommending you rush out and buy one.

There's also the nagging feeling that maybe, just maybe, traditional gaming isn't the best use of VR's capabilities. This is backed up by the fact that it's individual experiences that stand out most—a large whale swimming alongside you, the feeling of vertigo, looking down at a virtualized Tokyo, or the gut-clenching experiences of oh-so-many roller coaster rides. It's here that the Mixed Reality angle, and Microsoft's more educationally savvy offerings, could produce that much-needed killer app. We're happy to hope something good can be born out of Microsoft getting in on the game, but it hasn't emerged just yet.

The HTC Vive was released at $600, and the Oculus Rift can be picked up for under $500, so the fact that the Lenovo Explorer is available from $350 is to be commended, especially as it has an improved specification over first-gen gear. However, the market needs to move on even faster, and while a positive step, we expect even more to get the PC back on top. At this point, that's going to require a revolution, rather than this subtle evolution. –**ALAN DEXTER**

VERDICT
7

Lenovo Explorer

+ LUCID High resolution displays; comfortable; wireless controllers; good price.

− NIGHTMARE No headphones; lacks individual lens control; movement loses focus; still no killer apps.

$450, www.lenovo.com

SPECIFICATIONS

Combined Resolution	2880x1440
Displays	2.89 inches
Field of View	110 degrees
Refresh Rate	90Hz
Connectivity	HDMI 2.0, USB 3.0, 3.5mm jack, Bluetooth 4.0
Sensors	Inside-out motion tracking, room scale
Headphones	None
Weight	13.4oz

Future

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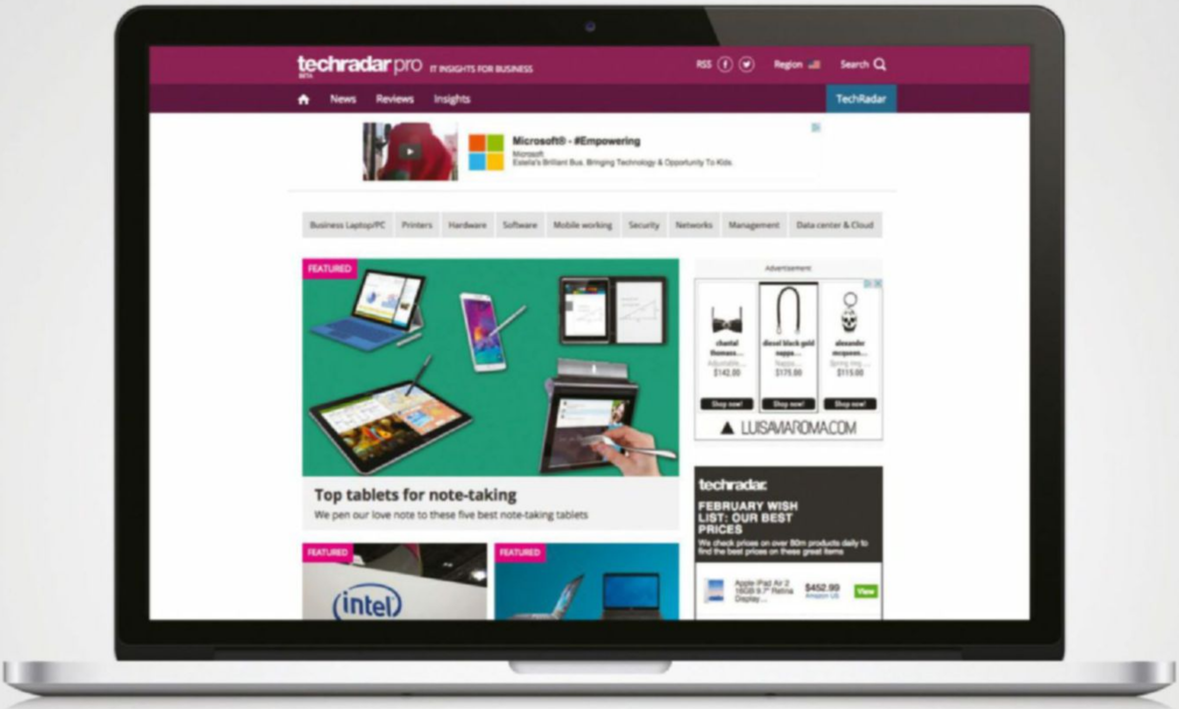
IT INSIGHTS FOR BUSINESS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We pen our love note to these five best note-taking tablets

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Crucial MX500 500GB

An extra two years makes all the difference

crucial
by Micron
2.5-inch SOLID STATE DRIVE

THE MARCH OF TECHNOLOGY waits for no man. Unless the poor sap in question relies upon the SATA interface for his PC storage connectivity. In which case, technology is happy to sit down and soak up the view.

That's because of the limitations associated with SATA. First, there's a hard bandwidth limit of around 550MB/s, net of overheads. Then there's the fact that SATA is reliant on the AHCI control protocol, which hails from the mists of 2004, making it positively antediluvian in tech terms. Critically, it also means that AHCI was never conceived with solid-state storage in mind. It was designed to suit magnetic drives and read heads, not NAND chips.

One of the more obvious upshots is the practical cap it puts on random access performance. AHCI isn't optimized to allow SSDs to give their best when it comes to random access performance. With that long-winded preamble in mind, may we present Crucial's newest SSD, the MX500.

It's a plain old SATA drive, so all of the above limitations apply. Not that this should be a huge surprise, given Crucial is yet to launch a PCI Express-based drive for consumers that supports the more modern NVMe control protocol. That, in turn, reflects the fact that the market for add-in drives such as this remains dominated by SATA, regardless of its limitations.

The MX500 does bring some substantial hardware changes to Crucial's flagship line of SSDs. It gets parent company Micron's new 64-layer 3D TLC NAND memory. Just as important is the switch from Marvell to Silicon Motion for the controller chipset. That said, the raw specifications are little changed over the previous MX300 drive—and, indeed, the MX200 before that.

COVER STORY

The exceptions include a much improved 350TB data endurance rating, and an upping of the warranty from three to five years. It's the latter that marks out the MX500 as a drive that can trade blows with premium SATA offerings. Five years is very impressive. In subjective performance terms, of course, you'd do well to pick one premium SATA drive from another much of the time. But five years versus three years is a difference you'll really appreciate in the form of an extra two years of full confidence that you're covered.

For the record, the MX500 delivers solid, if predictable, numbers in the bulk of our benchmarks. Peak reads rock in at 564MB/s, writes at 522MB/s. Random writes of 39MB/s are decent for a SATA drive, ditto the 99MB/s for random writes, even if the latter is a little slower than Crucial's own BX300 budget drive. You can say the same for the 147 seconds it racks up on our internal file copy test.

In reality, most of those numbers are fairly academic, in that they're free from obvious flaws. The same goes for our subjective experience with the drive shunting data around. It doesn't suffer from any obvious glitches or the infuriating cache-related slowdowns that some drives exhibit. That's true despite the fact that the MX500 has an SLC write caching mode, designed to accelerate bursty workloads—we didn't find a usage scenario where we could detect its limitations.

If the new MX500 therefore establishes itself as a solid all-around SATA SSD, the final test involves bang for buck. As we go to press, this 500GB iteration can be had for just $135. That's seriously competitive for a drive with such solid performance and a five-year warranty. It's not often that a SATA drive makes such a compelling case for itself, such is the maturity of this particular market. But the price and that five-year cover are a killer combo. It really is hard to think of many convincing reasons to buy anything else. **–JEREMY LAIRD**

VERDICT
9
KICK ASS

Crucial MX500 500GB

+ BEST ACTOR Solid all-around performance; five-year cover; great price.

– SUPPORTING CODPIECE It's still a SATA drive; PCI Express SSDs are far faster.

$135, www.crucial.com

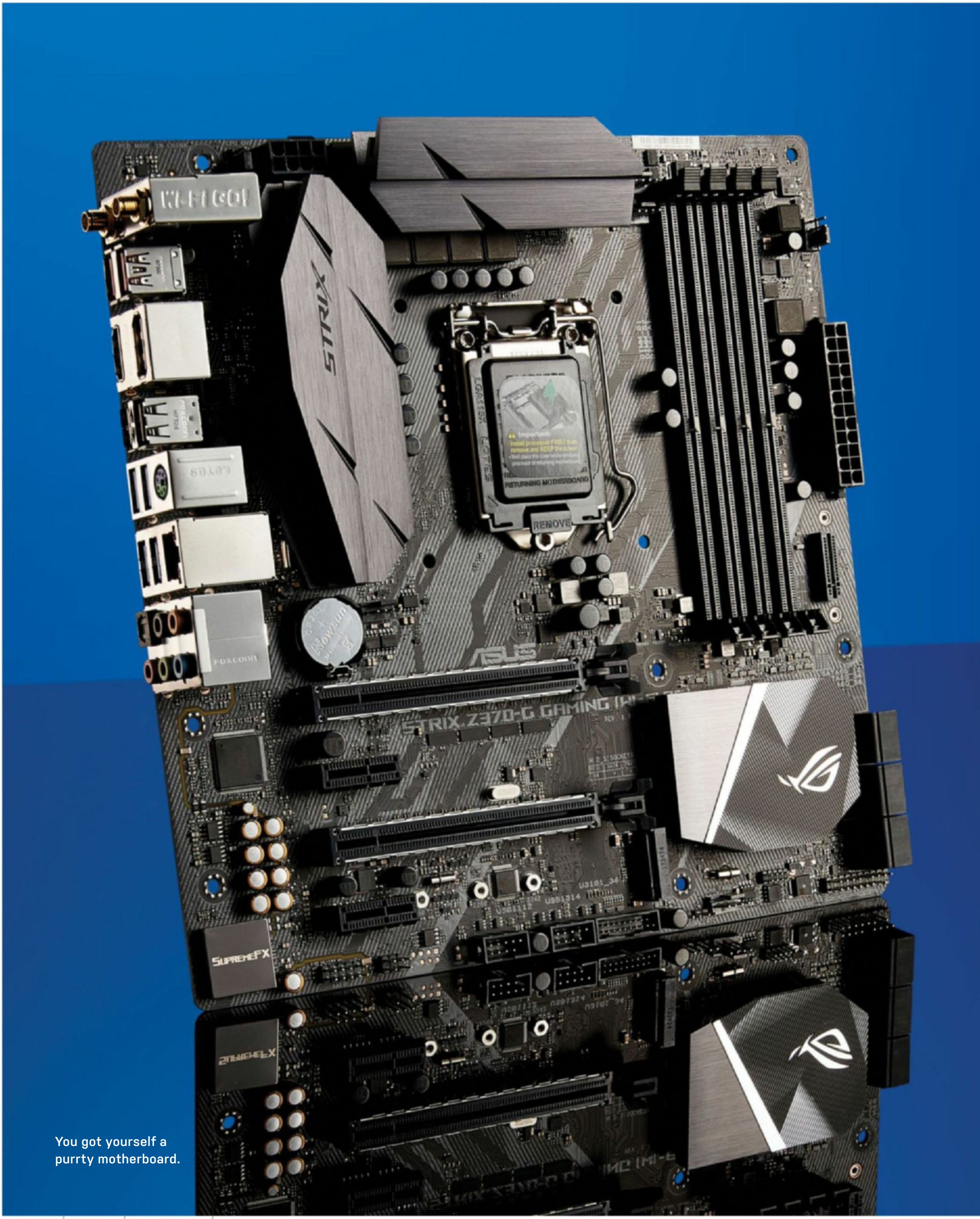
BENCHMARKS

	Crucial MX500 500GB	**Crucial BX300 480GB**
CrystalMark Incompressible Sequential Read (MB/s)	**537**	526
CrystalMark Incompressible Sequential Write (MB/s)	478	**486**
CrystalMark 4K Random Read (MB/s)	**39**	33
CrystalMark 4K Random Write (MB/s)	99	**130**
ATTO Sequential Read (MB/s)	**564**	**564**
ATTO Sequential Write (MB/s)	522	**526**
30GB Internal File Copy (Secs)	147	**127**

Best scores are in bold. Our test bench consists of an Intel Core i7-7700K, an Asus Maximus IX Hero, an Nvidia GeForce GTX 1080, 16GB of Corsair Dominator Platinum DDR4, and a Samsung 850 Evo 250GB OS SSD.

SPECIFICATIONS

Capacity	500GB
Interface	SATA
Control Protocol	AHCI
Controller	Silicon Motion SM2258
NAND Type	64-layer TLC
Sequential Read	560MB/s
Sequential Write	510MB/s
Read IOPS	95K
Write IOPS	90K
Warranty	Five years


WI-FI GO!
STRIX
ASUS
STRIX Z370-G GAMING (WI-FI)
SUPREMEFX
FOXCONN
RETURNING MOTHERBOARD
REMOVE

You got yourself a purrty motherboard.

Asus ROG Strix Z370-G Gaming

Number one of three

MOTHERBOARDS LIKE THIS don't come around often. Perhaps it's due to Coffee Lake's minuscule power requirements, or maybe because Intel's mature platform needs little iteration between generations, but the microATX form factor, as we've mentioned in this very issue, doesn't seem to get much love from mobo designers. Which is a shame, because it's a perfect combination of form and function.

Just take a look at the arsenal attached to this 9.6-inch square of PCB joy: two M.2 PCIe SSDs, six SATA 6GB/s ports, dual PCIe x16 slots, USB 3.0 header, five PWM fan headers, and support for 64GB of DDR4 running all the way up to 4,000MT/s. Pretty snazzy. It's not a huge amount, but it's more than enough to forge any number of RAID arrays, run SLI and XFire configs, and pump a decent amount of airflow around all at the same time.

It's a beautiful thing to be so perfectly balanced, and the industry seems to have forgotten just how important such balance is. It's ironic, really, when you consider how much we've moved away from pure performance, and leaned more toward power savings to try to balance our semiconductors more.

That aside, Asus's ROG Strix Z370-G motherboard is a solid choice on more than just form factor and function. Let's talk aesthetics. The bare-bones brushed steel look, littered with stripes across the board, looks crisp and sharp. What limited RGB lighting there is, is confined entirely to the logo on the chipset. There's no rear I/O cover, no audio cover, no armor. It's nice and simple. Yet, surprisingly, it's still sophisticated because of it. It's one of the main reasons we chose this board for last issue's "Build It" feature. Nowadays, building a themed black and white system is no easy feat, especially given the level of RGB and lighting baked into almost everything. So, the subtle lines and color of components really made this board stand out against the other options currently available. Admittedly, we didn't have a whole lot of choice—a meager three microATX form factor mobos sit in the Z370 space right now, so it was hardly a tough call, but still.

As far as performance is concerned, the Z370-G falls exactly where you would expect it to. Asus's Z370 philosophy is still pretty resolute: Power draw is quite high in contrast to the competition, along with clocks edging up ever so slightly because of it. That's not so great when it comes to temperatures, but it is good for stock performance.

In Cinebench we saw figures hit the 1,539 mark, and X265 hit 30.47fps, compared to MSI's Z370 Godlike Gaming which managed 1,422 and 28.32 respectively, albeit at far lower temps than Asus's power-hungry offering. That aside, there's little to report—performance is exactly what you'd expect from a Z370 motherboard.

Ultimately, then, if you're after a microATX motherboard on the Z370 platform, the Z370-G is likely your best bet. Its smooth, clean style, solid performance, and intuitive BIOS make it a standout choice, and the best of three in a world of slim pickings. **–ZAK STOREY**

BENCHMARKS

	Asus ROG Strix Z370-G Gaming	Asus Maximus X Hero
X265 (Avg fps)	30.47	**30.65**
Cinebench R15 Multi (Index)	1,539	**1,553**
Fry Render (Seconds)	**133**	**133**
AIDA64 Memory Latency (ns)	48.4	**48**
Power Draw Idle (Watts)	**65**	**65**
Power Draw Load (Watts)	204	**198**
CyrstalDisk Sequential Read (MB/s)	**550**	532
CrystalDisk Sequential Write (MB/s)	**525**	501
Far Cry Primal (Avg fps)	**42**	**42**
3DMark: Fire Strike Extreme (Index)	**9,816**	9,785
Maximum OC Achieved (GHz)	**5.2GHz**	**5.2GHz**

Best scores are in bold. Our test bed consists of a Intel Core i7-8700K, 16GB (2x 8GB) of Corsair Dominator Platinum DDR4 3200, an Nvidia GeForce GTX 1080, and a 500 Samsung 850 Evo SSD. *Far Cry Primal* tested on Ultra settings at 4K.

VERDICT 9 KICK ASS!

Asus ROG Strix Z370-G Gaming

+ **MICRO BLACK HOLE** Styling; performance; price.

− **MICRO SCOOTER** Quite high power draw.

$184, www.asus.com

SPECIFICATIONS

Chipset/Socket	Z370/LGA 1151
Form Factor	MicroATX
Memory Support	64GB DDR4 @ 4,000MT/s
M.2/U.2 Support	2x M.2 PCIe x4
SATA Support	6x SATA 6Gb/s
Max PCIe Support	2x PCIe 3.0 x16 (x8/x8)
Rear I/O	4x USB 3.0, 2x USB 3.1 Type A, combi port, DisplayPort, HDMI, Intel Gigabit Ethernet, 5.1 audio, TOSLink optical audio out

ViewSonic VP3268-4K

The ideal affordable almost-pro panel?

IT'S A TRUTH not acknowledged universally enough, that desktop PCs get a raw deal when it comes to pixel count. After all, fairly affordable laptop PCs with full 4K panels are now widely available. Heck, 1440p is no longer anything special for a smartphone.

Back on the desktop, 4K is about as good as it gets, despite the much larger physical size of desktop panels. At least, it is unless you're willing to spend megabucks. The net result is that desktop monitors can't hold a candle to the best portable devices when it comes to pixel density, and thus display crispness and detail. The mitigating factor, of course, is that Windows, and indeed the Internet at large, still doesn't do a great job of supporting high DPI displays.

That's part of the context for ViewSonic's new 32-incher, the VP3268-4K. It threads the needle between smaller 4K panels (that throw up issues in Windows when running the scaling above 100 percent in order to maintain legibility) and larger 40-inch-plus 4K panels (that remain legible at 100 percent scaling, but suffer from relatively fat, ugly pixels); 32 inches at 4K is something of a sweet spot.

The VP3268-4K's other defining feature is its status as a semi-pro quality display. For $820, you can't expect to get a full professional grade monitor, especially not one of this generous scale, but ViewSonic has delivered a nice display all the same.

The foundation of the VP3268-4K's excellent performance is a gorgeous IPS LCD panel. In most regards, it's a conventional rather than cutting-edge panel—it doesn't sport snazzinesses such as a quantum dot-enhanced backlight or super-high refresh rate, for instance. Instead, it delivers on core image fidelity.

Subjectively, it's a lovely thing to look at, alive with convincing, natural hues, and offering plenty of contrast. The latter, incidentally, is rated at 1,300:1, which is a useful step up on the typical 1,000:1 static contrast that most IPS panels are pegged at. Out of the box, you'll struggle to find any significant flaws or defects. OK, the VP3268-4K probably isn't as punchy and saturated as Asus's quantum dot-enhanced ProArt PA329Q, but that is a substantially more expensive panel. With its super-slim bezel, high-quality enclosure, and fully adjustable stand augmenting the classy visuals, the overall experience is extremely impressive. We also noticed an absence of input lag and decent pixel response, the latter enabled by the availability of pixel overdrive in the OSD menu. This isn't pitched as a gaming monitor, in other words, but you can still have a darn good time playing games on the VP3268-4K.

The VP3268-4K is also impressive by the numbers. ViewSonic ships it with support for an extensive array of color spaces, including sRGB, Rec. 709, SMPTE-C, and EBU, each of which is pre-calibrated to DeltaE levels of below 2.0, and confirmed in the factory calibration report. Toggling between these modes is a cinch via a comprehensive set of OSD menu options. While really serious professionals may prefer to calibrate the panel themselves, for those who lack the hardware or inclination to self-calibrate, the pre-calibrated presets will come in very handy.

The panel itself is also a true 8-bit affair, with support for a 14-bit look-up table; 10-bit per channel color is also offered, albeit through dithering, rather than native support. For native 10-bit color, you'd have to spend a lot more money. Overall, then, the new VP3268-4K doesn't break new ground. It isn't quite the last word in professional features. It's not the ultimate gaming panel. But it is a fantastic screen at a competitive price. **–JEREMY LAIRD**

VERDICT
9

ViewSonic VP3268-4K

+ OSCAR WINNER Fantastic IPS panel; strong feature set; great slim-bezel style.

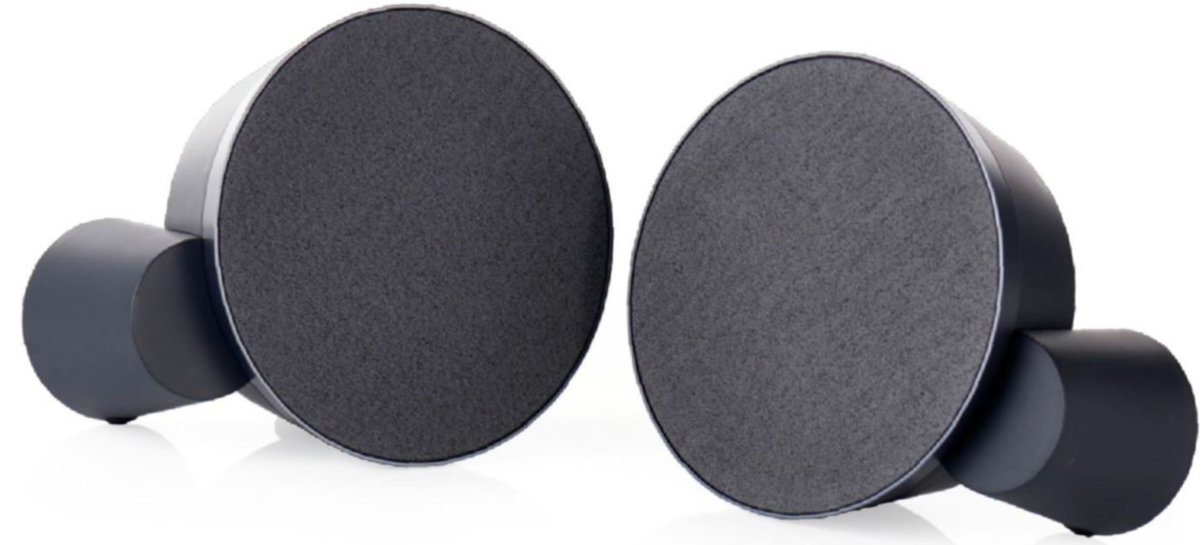
− NOT EVEN NOMINATED Not quite a full-pro panel; Asus's pricier ProArt PA329Q is also punchier.

$820, www.viewsonic.com

SPECIFICATIONS

Panel Size	32-inch
Native Resolution	3840x2160
Pixel Density	138 ppi
Panel Type	IPS
Maximum Refresh	60Hz
Response	7ms
Contrast	1,300:1
Display Inputs	2x HDMI, DP, Mini DP
Connectivity	5x USB 3, 3.5mm audio
VESA Mount	100 x 100mm
Warranty	Three years

ViewSonic's latest 4K monitor looks good in more ways than one.



Logitech MX Sound 2.0

Round sound crowned or downed? Stick around

GIVE LOGITECH'S flair wizards their due: The MX Sound speakers are a handsome pair. The super-flat cloth-covered drivers, in neutral gray, avoid calling attention to themselves, yet unavoidably become a focal point on your desk. They go so far into neutral that they come out other side, their absence of visual noise drawing the eye like an optical illusion, particularly if your usual PC environment is busy. Their clever circular shape, which stands each speaker at a 20-degree ear-pointing lean, by resting on the rear of the outer bass tube, is pretty cool—although it leaves each speaker unit with an unusually wide footprint, which places heavy demands on your available space. What controls there are—white LED volume buttons and a Bluetooth connector/indicator combo—remain hidden behind the cloth of the right speaker, until they eerily light up when you bring your hand near. While the cloth is likely to become filthy if you poke them with any regularity, they're useful enough.

Thankfully, the MX Sound set is smart enough that you don't need any more controls. The right speaker includes a pair of 3.5mm jack sockets for individual inputs, and Bluetooth makes three. Switching between them is seamless. Pause one, play the other, and you're away; or hell, why not play multiple sources at the same time? The Bluetooth connection seems strong and connects without argument, but be prepared for some volume fluctuations if you're switching sources, as the MX Sound automatically flips to your device's Bluetooth volume level if you start playing wirelessly, or even if your phone happens to ding out an alert. There's an additional 3.5mm jack for headphone output, which cuts the signal to the speakers if you have your cans plugged in, but it's a shame that's as far as the pass-through goes. If you're a serious headset user, you're probably already using a USB connection, but some way of routing a microphone through to the PC would have been handy—and a speakers/headphone toggle even more so.

NO SENSE OF DIRECTION

It's hardly worth griping about what could have been, though. What's there is good, in terms of construction and design. So how about sound? Logitech's all-too generic boast is that these 24W peak speakers "deliver balanced audio that accurately reproduces the sound the artist intended." Perhaps. Maybe if you manage to position the speakers so that their bass response tubes fire well, and you also place your head in precisely the right sweet spot—these are some of the most directional and environmentally dependent desktop speakers we've ever heard.

There's no doubt their overall balance is pleasing and powerful, with decent low-end rumble and great stereo separation. They generally sound great when firing out music. There's no distortion when driving them hard, no noticeable dropped frequencies when running quiet. It's a well constructed musical sound stage. Listening to speech, though, can highlight a distracting tubular reverberation in the mid-range—an artefact of the bass ports—and moving one's head even slightly from the mid-point between the speakers makes a jarring difference, unless they're sufficiently deep-set on your desk.

Realistically, we're picking a lot of holes in what is a stylish, competent set of 2.0 speakers, pitched at just the right price point. They're by no means a disappointment. But we've been on Logitech's beat a lot recently, and for the most part, it's been a gadget-filled pleasure. The company is on fire, making outstanding gear. These speakers, though, don't carry the same level of finesse, innovation, or ingenuity that recent efforts in Logi's peripheral line have achieved. They're good, but not exciting. **–ALEX COX**

VERDICT
7

Logitech MX Sound 2.0

+ **AUDIOPHILE** Clever looks; balanced sound stage at all volumes; multiple inputs.

− **AUDIODEFILE** Bluetooth volume silliness; awkwardly directional sound.

$100, www.logitech.com

SPECIFICATIONS

Total Watt (Peak)	24W
Total Watt (RMS)	12W
Connectivity	Bluetooth 4.1, 2x 3.5mm
Output	3.5mm headphone jack
Dimensions	6.3 x 7.5 x 3.3 inches
Weight	3.9lb
Warranty	One year

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Adata XPG EMIX H30 + SOLOX F30

So close, yet so far

WHEN A MANUFACTURER, new to the subtleties of audio-speaker development, launches a headset, the typical reaction of reviewers is to look like a slapped badger. The effect is compounded as soon as their favorite testing track starts to play, pumping out some indistinguishable noise from those dynamic drivers, nothing like the original clarity of the musical delicacy they once loved. The face falls, and the sadness rises. The reason why stems from the corporate world's disregard for, or inability to understand, its audience. Bean counters and CFOs looking for a quick buck push for corners to be cut. Frequency range and sensitivity suffer, distortion is ignored, and the oh-so-comical "humans can only hear 20-20,000Hz anyway" phrase gets touted in that herp derp attitude often expressed by those who have no love or appreciation of music.

It's a sad but all too often occurrence that we've seen from many a company trying to break into this sector. The one and only manufacturer ever to buck the trend was Kingston. Its HyperX Cloud headset took the world by storm, with a fantastic spec sheet, and an equally impressive price. It's still one of the most recommended budget-to-mid-range headsets you can buy today, and with damn good reason. Believe us when we say, then, that Adata's XPG EMIX H30, despite sitting in the Cloud's shadow, is also reaching for the sun. Or trying to, at the very least.

COUNTING THE COST

At first glance, the specs look promising. There's a pair of 53mm dynamic drivers, a sensitivity of 110dB, and an operational impedance of the standard, low-power 32 ohms. The frequency response does fall into that 20K range we castigated earlier, but when combined with the included USB DAC, it's possible to forgive it this one misdemeanor. All in all, when pumped through the included digital-to-analog converter, it sounds pretty good. You might even say very good, with little distortion, and a well-rounded soundscape, putting ample weight into both the bass and the treble. But then we'd be surprised if it didn't, given the $200 list price.

That's a lot of cash, especially for a gaming headset. And although it's good, it's got some tough competition, thanks to that effervescent price tag. Beyerdynamic's Custom Gaming and Sennheiser's Game One and Zero headsets all come in at a good $10–35 cheaper than the H30, and that's a problem. Especially when they feature drivers that far outstrip the two powering XPG's first foray into the market. Arguably, they don't come with an included USB DAC, but then, to be frank, they don't need it. They sound good on their own. Just plug and play, and they're good to go.

It's not all bad news, however. Thanks to an exceptionally well-cushioned headband sitting astride two self-adjusting rails, the two faux leather memory foam earcups put just enough pressure on your lobes to ensure a snug fit without leaking sound. Couple that with the DAC's impressive soundscape, and it rounds out the H30s as a good set of cans.

There's a lot to love—and a lot not to love—with XPG's first audio outing. Its robust design, inclusive feature set, and exceptional comfort make it a good headset. But that's the problem: At $200, it needs to be more than good—it needs to be outstanding. The fact that it has to compete against already well-established audio brands, such as Sennheiser and Beyer, at a far higher price, just doesn't bode well for this boisterous pair of noise-pushers. Ultimately, if the plucky newcomer had decided to pursue a more robust, affordable headset, with an emphasis on driver quality rather than inclusive gimmicks, it could well have been on to a winner here. Unfortunately, as things stand, it's just a solid "7" from the *Maximum PC* team. **–ZAK STOREY**

VERDICT
7

Adata XPG EMIX H30 + SOLOX F30

⊞ **SUPER F7 GOOD + 30** Good soundscape; super-comfortable; interesting design.

⊟ **ALT-F4** Price and competition; poor driver quality; too many cables.

$200, www.xpg.com

SPECIFICATIONS

Driver Type	53mm dynamic
Impedance	32 ohms
Frequency Response	20–20,000Hz
Design Style	Closed-back
Microphone Type	Unidirectional
Connectivity	3.5mm + USB DAC
Cable Length	8 feet

Razer Basilisk

Is Razer ushering in a rodent revolution, or just a squeaky clean revamp?

APPARENTLY, THIS IS the world's most advanced FPS gaming mouse. It probably says a lot about the level at which we play FPS games, that we struggle to imagine how peripheral advancements might meaningfully enrich the experience, but Razer's armed its latest Basilisk with an arsenal of impressive specs to make that argument paramount. This $70 mouse has a max sensitivity of 16,000 dpi, a removable clutch tucked under the LMB to bring that DPI right down for precise aiming, customizable RGB lighting (of course), and even a scroll wheel tension adjustment. Crucially, it doesn't feel over-designed.

If gaming mice are guilty of anything, it's that. Entire keyboards nuzzled away by the thumb rest. On-the-fly dimension adjustments. Teeny-weeny weights that spill over your desk, and make family members suspect you're a drug dealer. Mice simply don't need a lot going on in order to function well, so congratulations to Razer for keeping the appearance and operation of the Basilisk nice and simple.

This isn't an ambidextrous model, so assuming you're a righty, it's a particularly comfortable mouse for palm grip, and perfectly acceptable for the claw, too. Those who like to float around by fingertip grip might find the thumb rest a little awkward, though. We're not enamored by the rubberized finish on the sides of this model, and already a disconcerting build-up of hand scum is starting to accumulate in the grooves there. Perhaps keeping the build materials uniform across the chassis might have made for a cleaner and more aesthetically pleasing Basilisk.

Still, any points lost due to those rubber sides are gained right back by the adjustable scroll wheel tension. It sounds like a little, incidental detail. All right, it absolutely is that. But if you're playing awkward games like *My Summer Car,* in which screwing in bolts using the mouse wheel constitutes a large part of the experience, having a fast-scrolling rodent is a boon. Simply adjust a secret, extra wheel on the underside of your mouse to adjust to taste. Even at minimum tension, it doesn't free-wheel like a Logitech mouse, however, which is a bit disappointing—just a note for the wheel aficionados. A word on the clutch: It's smart and comfortable, and it works well. It's held in place magnetically, so you can pop it out and give your thumb more room if you find you're not using it. A well-executed bit of design from the Xbox One Elite controller playbook.

ON THE DOT

In terms of performance and accuracy, it's one of the smoothest and most reliable trackers we've tested, and, as such, it is indeed ideal for FPS use. We're not sure how many people will use that insane 16,000 dpi setting in-game, but we're guessing we'll be able to discern them from the crowd by the fact they're spinning like a gyroscope at all times. DPI can be adjusted in a snap using the two buttons south of the mouse wheel, and as you'd expect, you can adjust the five different gradients using Razer's own software.

Right, yes. The software. This won't be the first or the last time Razer is chastised for this, but submitting an email address in order to create a Razer account just so you can change the color scheme of your mouse isn't acceptable. Stop doing this. Corsair doesn't do it. SteelSeries doesn't do it. Stop it, OK? OK. Except for that issue, the Synapse software does everything it needs to—DPI gradient adjustment, polling rate, RGB profiles, and even custom calibration for use on Razer's various mouse mats and pads. You can save profiles in the software, and later switch between them using—once again—a button on the underside of the Basilisk. It's not as handy as having a button somewhere under your grip, but better that than accidentally pressing it all the time mid-game, eh?

That's a lot of nice, thoughtful features for $70, and only Razer's software sign-up demands diminish that otherwise generous package. However advanced this Basilisk may or may not be, it's a pleasure to take with you into an FPS. **–PHIL IWANIUK**

VERDICT
8

Razer Basilisk

⊞ **RAZOR SHARP** Comfortable; feature-laden.

⊟ **RAZOR BURN** Software hoop-jumping.

$70, www.razerzone.com

SPECIFICATIONS

Sensor Type	Razer 5G optical
Sensitivity	16,000 dpi
Sensor	Pixart PMW3588
Polling Rate	1,000Hz
Programmable Buttons	8
LEDs	Customizable RGB
Cable length	7 feet
Weight	3.8oz

NZXT H400i

A lotta dollar for a lotta case

AH MICROATX, the bastard child of the form factor family. Sitting somewhere between the juggernauts ITX and ATX, it takes the best of both worlds, and condenses it into a feat of efficiency and expandability. It's one of our favorite form factors. If you're after a smaller rig, with support for multiple GPUs, more memory, and plenty of I/O, without going huge, it's a happy compromise. Problem is, being the Goldilocks of the PC world isn't good enough in today's age of rapid releases.

In a world of bi-yearly processor launches, manufacturers simply don't have the time to develop boards for this form factor anymore. It's just not that important in the grand scheme of things. It lacks the mainstream desirability of ATX and the engineering "wow!" factor of ITX, so allocating resources to it doesn't make much sense, as far as AIB partners are concerned. And that's the problem: There's not enough microATX boards.

Let's break it down. For a brand-new mid-range rig right now, if you're after Ryzen and X370, you can forget it. There are no boards—plenty of B350 variants, but no premium. Turn to Coffee Lake and Z370, and you'll find just three. Threadripper? There's one on the way from ASRock, but it hasn't been released just yet. And for X299, there's a grand total of just one board. Slim pickings indeed.

Seemingly, then, NZXT's H400i is a bit out of place in this world of ATX and ITX giants. It's a case that sits right in the center of this middle-ground massacre, yet it really doesn't deserve to, because it's a fantastic piece of design. Not that that'll surprise anyone, given just how impressive its father, the H700i, is. Those clever features that NZXT crafted around the brilliant structure of that mid-tower monster migrate well into the smaller form factor of this microATX wonderdog. Whether that's the intuitively folded cable bar, the smart SSD mounts, PSU cover, smart fan controller, tempered glass, and more, it all just works—and works well. Yet there's one difference: price. And it's a doozy—a $50 doozy, to be exact. And in a market where DDR and GPU prices are skyrocketing ever higher, it's a price drop that's very much welcomed.

Where the H400i really shines, however, is with its cooling potential. Radiator and fan mounting compatibility is exemplary. Whether it's an AIO, custom loop, or air tower you have in mind, it's a case that can very much do it all. No, seriously—two 140mm fans in the front, two in the roof, and a 120mm in the rear for standard airflow alone make it killer for any air-cooled system. Combine that with the fact that you can pack a 280mm radiator in the front and a 120mm in the back as well, and it soon starts to turn heads in the liquid-cooling world, too. On top of that, you get that gargantuan front panel, perforated with holes along each and every side, acting as both a stylish design choice and a fantastic air intake for the two 140mms located up front.

Storage support, on the other hand, does come unstuck a little. Although you can install up to four 2.5-inch drives, there's only support for a single 3.5-inch, so that's something to take into account. Plus, of course, there's no 5.25-inch bays—they've seemingly gone the way of the dodo at this point.

If nothing else, the H400i is a perfect excuse to migrate toward the microATX form factor. Its exceptional design, brilliant use of materials, and nice price savings over the bigger H700i all combine to make it one of the best cases we've ever got our hands on. –ZAK STOREY

VERDICT **9**

NZXT H400i

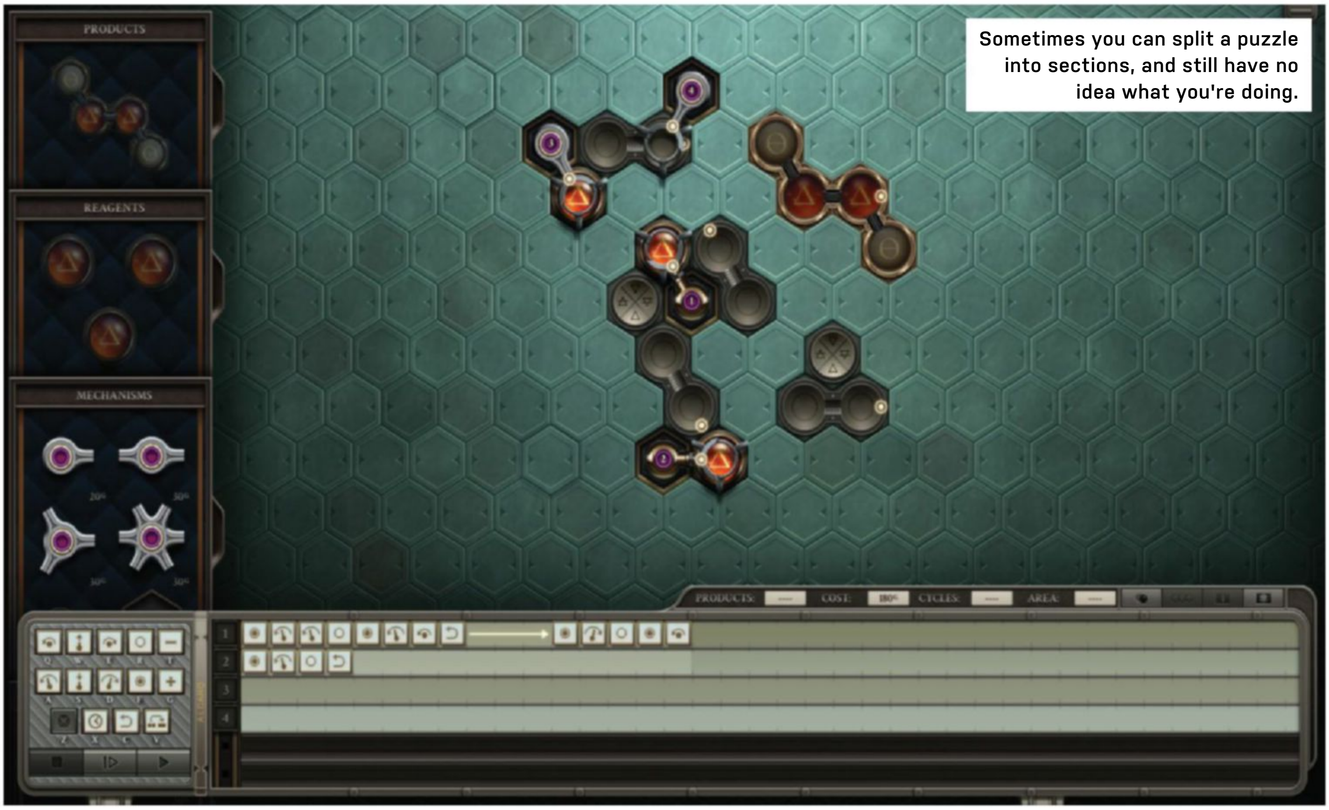
⊞ **JON SNOW** Paint finish; materials; cooling support; cable management; ease-to-build.

⊟ **JOFFREY BARATHEON** Limited motherboard selection; a bit pricey.

$150, www.nzxt.com

SPECIFICATIONS

Form Factor	MicroATX
Motherboard Support	MicroATX, Mini-ITX
Colors Available	Matte white, matte black, black and red, black and blue
Window Available	Windowed only
3.5-Inch Support	1
2.5-Inch Support	3+1
Radiator Support	280mm front, 120mm rear
Fan Support	2x 140mm front, 2x 140mm roof, 1x 120mm rear
Dimensions	8.3 x 16.4 x 16.6 inches
Graphics Card Clearance	16.18 inches
CPU Tower Clearance	6.46 inches



Sometimes you can split a puzzle into sections, and still have no idea what you're doing.

Opus Magnum

If all that glisters isn't gold, we can soon sort that out

THE SCREENSHOT above doesn't look like much. It's nice and sharp, sure, and if it matters, we can confirm it was produced by an Nvidia GTX 1070 Ti that's had its core and memory clocks pushed beyond factory settings. A GPU isn't even listed in the game's recommended specs on Steam—you could run it on integrated graphics.

So why is it here? Because it's everything we want at this time of year, now the scant optimism of January has worn off, and the remaining months lurk ahead like the eyes of alligators caught in a flashlight. *Opus Magnum* is pure. It's clean. And once it's got its claws into you, you'll spend as much time with it as any *Assassin's Creed* or *COD.*

The premise is simple. As head alchemist at a great house in a steampunk world, it's up to you to make stuff. Chemical stuff, such as hangover cures, airship fuel, lead into gold. To do this, you use a Transmutation Engine, a system of moving arms and eldritch glyphs that take an input element and change it into the required output. There's no definitive right way to do it, so eventually you'll lash together something that works, and unlock the next puzzle.

Simple enough, but that machine you made on the last puzzle could be better; it could be smaller, cost less, or make the same end product in fewer steps. You could even remake it so that it's more aesthetically pleasing—there's even a special glyph, which costs nothing, you can use to this end.

Turning lead into gold, it turns out, is easy. Try making airship fuel, which requires four elements to be bonded. Surprise! The most you can bond with a single glyph is three. So why not use piston arms that can change length, or a track that an arm can move up and down to manipulate your emerging molecule into just the right position to have another go on the bonding glyph, and have new elements grafted on?

The trouble comes when you try to visualize what's going to happen in your mind, but it doesn't play out that way when you test your eventual machine. At first, we blamed the instruction tiles—you place them along tracks at the bottom of the screen, one track for each arm, rather like the timeline of a video-editing application—because the tile for arm rotate looks rather like the one that pivots your creation, and we were muddling them up.

But no, the game is fine, it applies its smattering of rules—really, there aren't many—completely fairly and consistently. It's our brains that are wrong, and by the time the end of the first set of levels approached, we'd trained them to think the way we imagine developer Zach Barth does. Barth, under the name Zachtronics, also made *SpaceChem* and *Shenzhen I/O,* so veterans of those titles will know exactly what to expect here.

While it doesn't look much, there's an austere beauty in the contraptions you build, and the ability to save them out as animated GIFs is a touch of genius. Leaderboards pit you against friends, and a puzzle editor, combined with Steam Workshop support, guarantees a never-ending supply of brain-hurting alchemical combinations. This is a great work indeed. **–IAN EVENDEN**

VERDICT
9

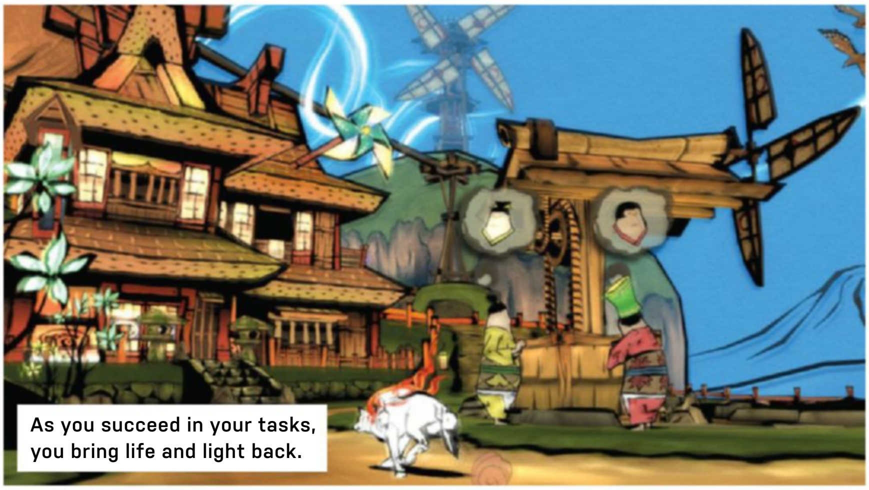
Opus Magnum

+ TRANSMUTATION Compelling puzzling that runs on anything.

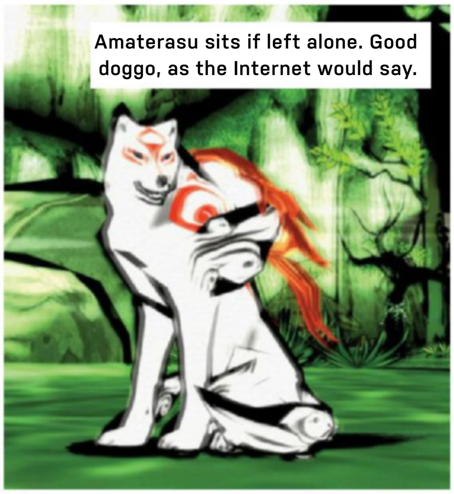
– TRANSYLVANIAN A few tiles can be confused; gets really, really hard.

RECOMMENDED SPECS 2.0GHz CPU; 4GB RAM; GPU capable of 1080p.

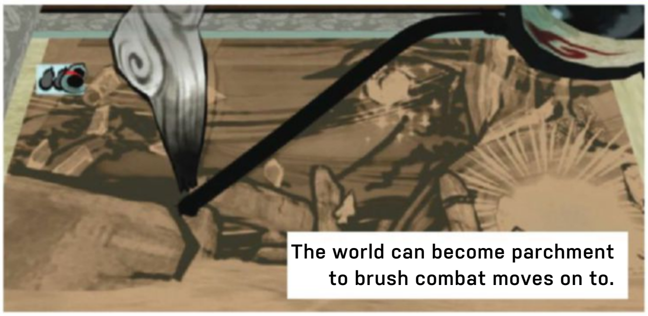
$20, www.zachtronics.com, ESRB: Not rated



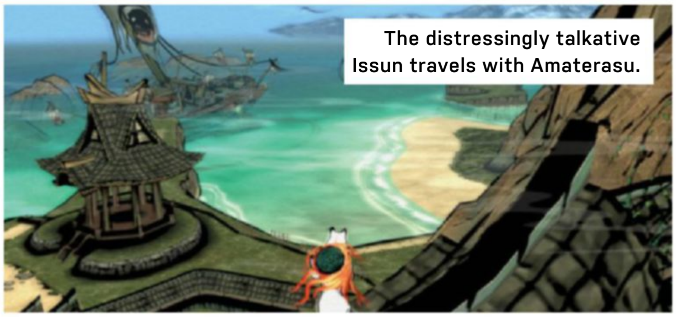
As you succeed in your tasks, you bring life and light back.



Amaterasu sits if left alone. Good doggo, as the Internet would say.



The world can become parchment to brush combat moves on to.



The distressingly talkative Issun travels with Amaterasu.

Okami HD

Lone wolf becomes the leader of the pack

IN THE WORLD OF THE PC, 2006 feels like a very long time ago. It was the year of Nvidia's pre-GTX 7-series GPUs, with 256MB of video RAM a common feature. Meanwhile, Sony's PlayStation 2 (with its 32MB of main RDRAM and 4MB of video RAM) was driving all before it in the console space, backed by the sort of Japanese developers Microsoft's Xbox could only dream of. *Okami* was one of the final games before the platform was retired in favor of the PlayStation 3.

That's where it could have remained, but every couple years *Okami* is dug up and remastered for a new generation of consoles, usually gaining resolution in the process. Which is why a game that once fitted on a DVD takes up 27GB of your hard drive now it's on PC—those 4K graphics.

We say "graphics" instead of "textures" for a reason—this isn't the sort of game about which you can wax lyrical on the quality of the geometry and the normal mapping. With a style inspired by ink-wash painting, *Okami* looks as magnificent today as it always has. More so now that we're dealing with eight million pixels rather than a scant 300,000. Turning a "Filter" option to "Light" rather than the default "Normal" in the graphics options brightens the game up, but otherwise the "High" visual settings result in a game that really shines.

Okami's slow start is pointed out every time it's re-released, and, yes, the 15-minute intro feels self-indulgent in these days of instant action with big weapons, as if it thinks it's a *Metal Gear* game or something. And *Okami's* makers, Clover Studio, had a similar studio-within-a-studio arrangement with Capcom as Kojima Productions had at Konami, eventually breaking free as PlatinumGames.

It's also very Japanese, and is beginning to feel old-fashioned. The plot melds a few different strands of Japanese mythology, the sumi-e look, originally created to take the strain off the wheezing PS2, meshing perfectly with a mechanic in which lead character Amaterasu—a wolf goddess—uses a celestial brush to paint the hurt directly on to enemies and obstacles.

There's more to it than combat, of course, and anyone who's played a *Zelda* game will recognize the structure as you wander the world solving puzzles, collecting weapons, powering up abilities, and bashing bad guys who appear from nowhere. The story is suitably epic, as you'd expect from a goddess, and the contrast with Amaterasu's humble nature is striking, particularly as the strength of humans' belief in her plays a part. It's dreadfully long, though—this is a game to clear a decent chunk of time for, the clunky old save points only coming up every half hour or so. The dialog can be a bit much if pressed for time, too—hitting a button to advance every line was feeling dated in 2006. In 2018, it's practically stone age. Difficulty can also be a problem, with spikes where you want them least.

If you've got the time to invest, though, there's nothing quite like *Okami*. The game feels special, as though a treasure has been revealed to you. It's just a shame that, when updating the game for 2018's monitors, a few more upgrades weren't performed to tailor it to 2018's gamers. –**IAN EVENDEN**

VERDICT
8

Okami HD

⊞ LUPINE Beautiful; timeless mechanics; epic storyline.

⊟ BOVINE Old-fashioned presentation and save system.

RECOMMENDED SPECS 3.4GHz Core i7-3770; 8GB RAM; GeForce GTX 950.

$20, www.okami-game.com, ESRB: T

LAB NOTES

ZAK STOREY, DEPUTY EDITOR

Benchmarks and Zero-Points 2018

It's time to take a look at how we test hardware going forward

UNTIL NOW, we've typically run with a single zero-point, and benched every system, regardless of spec, at 1080p. The idea being that all of our system reviews, "Build Its," and other features we produce pit the PC in question against a rig that's the closest example you can get to an average system at an average res. The problem, however, is that this isn't exactly fair. For instance, pitting a $9,000 Digital Storm rig up against last year's $2,000 zero-point doesn't tell us much, other than it's better (duh!). And vice versa—a $300 "Build It" versus that same zero-point, well, it just gets hammered. So now we're going to focus on three separate zero-points, at three separate resolutions and price tags. Each rig we review or build will then be tested against the zero-point that's closest to it in price. To keep things clear, these rigs were priced up on January 2, 2018, before everything went a bit nutty. We'll wait until June, then re-evaluate these price points, but hopefully the industry will have recovered by then.

2018 also means new benchmarks for systems and component reviews are being phased in slowly (as we accrue more results for them). We're going to deal them here, and tell you exactly how we use them for testing. So, on to the zero-points....

1080P SYSTEM: $1,050

Processor	AMD Ryzen 5 1600
Cooler	Stock Cooling
Memory	16GB (2x 8GB) Crucial Ballistix Sport LT @ 2,666MT/s
Graphics Card	EVGA GeForce GTX 1060 3GB
Motherboard	Asus Strix X370-F Gaming
OS Storage	250GB Samsung 960 Evo M.2 PCIe SSD
AD Storage	1TB WD Caviar Blue
PSU	450W Corsair CX450

1440P SYSTEM: $2,000

Processor	Intel Core i5-8400
Cooler	NZXT Kraken X52
Memory	16GB (2x 8GB) Corsair Vengeance LPX @ 2,666MT/s
Graphics Card	MSI GeForce GTX 1080 Armor
Motherboard	Asus Strix Z370-G Gaming
OS Storage	500GB Samsung 960 Evo M.2 PCIe SSD
AD Storage	2TB Seagate Barracuda
PSU	860W Corsair AX860i

4K SYSTEM: $3,400

Processor	Intel Core i9-7900X
Cooler	Corsair HX115i
Memory	32GB (4x 8GB) G.Skill Ripjaws V Series @ 3,000MT/s
Graphics Card	MSI GeForce GTX 1080 Ti Gaming X
Motherboard	Asus Prime X299-Deluxe
OS Storage	512GB Samsung 960 Pro M.2 PCIe SSD
AD Storage	2TB Seagate Barracuda
PSU	1,000W Corsair HX1000i

SYSTEM BENCHMARKS

You've probably already spotted these benchmarks several times over the last few issues, because we've been slowly phasing them in to our system reviews and builds. The table to the right is an example of what our 4K system benchmarks will look like going forward. We wanted benchmarks that were repeatable, simple for you to perform at home, covered serious work as well as gaming, and that were quantifiably easy to understand. It's always going to be a fine balancing act for benchmarks, but we feel that these provide the best all around look at any rig or feature we do.

EXAMPLE SYSTEM BENCHMARKS @ 4K

	ZERO-POINT	
Cinebench R15 Multi (Index)	2,178	3,500 (61%)
CrystalDisk QD32 Sequential Read (MB/s)	3,136	3,000 (-4%)
CrystalDisk QD32 Sequential Write (MB/s)	2,126	2,100 (-1%)
Rise of the Tomb Raider (Avg fps)	68	100 (47%)
Total War: Warhammer II (Avg fps)	42	65 (55%)
Tom Clancy's Ghost Recon Wildlands (Avg fps)	38	60 (58%)
3DMark: Fire Strike (Index)	6,988	10,000 (43%)

0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%

Re-Evaluating Reviews: Component Testing

A quick glance at the benchmarks we'll be using when we test hardware this year

NEXT UP ON the agenda is component benchmarks. We typically don't change a lot when we tweak these—mostly just new game titles, and the like—but it's often a good idea to take a step back, re-evaluate how relevant these are to genuine everyday use cases, and see whether there are any new benchies worth taking a look at.

Each set of benchmarks has its own unique permanent test bed. We can't list them here, because there's way too many. We always try to keep specifications similar between them where we can. For instance, our mainstream CPU tests always feature 16GB of DDR4 at 3,200, a GTX 1080, and a Samsung 850 Evo 500GB SSD (one SSD with a unique install dedicated to each platform), regardless. Jump up to X299 or TR, and we double the memory to allow for quad-channel, but still retain the rest of the spec. This helps ensure that we can easily compare figures across platforms.

So, what changes have happened this year? Well, they all stem around optimizing, and looking for bottlenecks. In our processor tests, we'll be using 1080p game titles, to try to hunt for those elusive high-end frame rate bottlenecks. For motherboard testing, we need to make sure the GPU and CPU are running in tandem efficiently, so 1440p is our go-to for that. For GPUs, we actually test our cards at all three resolutions, then report the figures for the resolution that makes the most sense.

We're also adding a new price-to-performance metric, for both CPUs and GPUs. This will fluctuate depending on the time of writing, but is calculated as the 3DMark: Fire Strike or Cinebench R15 Multi score, divided by the price the component is currently available for on Newegg. So, the GTX 1080 scoring 17,704 would get 21.3, while the GTX 1060 3GB with 10,251 would get 27.0; higher being better value for money.

MOTHERBOARD BENCHMARKS

	Product name	Product name
Cinebench R15 Multi (Index)	00.00	00.00
Tech ARP's X264 (fps)	00.00	00.00
Fryrender (m:s)	00.00	00.00
AIDA64 Memory Latency (ns)	00.00	00.00
CrystalDisk QD32 Seq Read/Write SATA (MB/s)	00.00	00.00
CrystalDisk QD32 Seq Read/Write M.2 (MB/s)	00.00	00.00
Power Draw Idle/Load (W)	00.00	00.00
Total War: Warhammer II @ 1440p (Avg fps)	00.00	00.00
Lowest Voltage @ xGHz (V)	00.00	00.00
Maximum OC Achieved (GHz)	**00.00**	00.00

PROCESSOR BENCHMARKS

	Product name	Product name
Cinebench R15 Single/Multi (Index)	00.00	00.00
Tech ARP's X264 (fps)	00.00	00.00
Fryrender (m:s)	00.00	00.00
AIDA64 Memory Latency (ns)	00.00	00.00
AIDA64 Memory Bandwidth (MB/s)	00.00	00.00
Power Draw Idle/Load (W)	00.00	00.00
Total War: Warhammer II @ 1080p (Avg fps)	00.00	00.00
3DMark: Fire Strike Integrated/Dedicated (Index)	00.00	00.00
Maximum OC Achieved (GHz)	00.00	00.00
Price-to-Performance (Index)	**00.00**	00.00

GRAPHICS CARD BENCHMARKS

	Product name	Product name
Middle Earth: Shadow of War (Low/Avg fps)	00.00	00.00
Total War: Warhammer II (Low/Avg fps)	00.00	00.00
Ghost Recon: Wildlands (Low/Avg fps)	00.00	00.00
Rise of the Tomb Raider (Low/Avg fps)	00.00	00.00
Unigine Superposition (Index)	00.00	00.00
3DMark: Fire Strike (Index)	00.00	00.00
Unigine Superposition OC (Index)	00.00	00.00
3DMark: Fire Strike OC (Index)	00.00	00.00
Power Draw Idle/Load (W)	00.00	00.00
Price-to-Performance (Index)	**00.00**	00.00

LETTERS

WE TACKLE TOUGH READER QUESTIONS ON...

> Review Granularity
> Perfect Prints
> Safe Mode Take 2

Scaled to Fit

I am a long-time reader of *Maximum PC*, and love the magazine. However, I've noticed a reluctance to use most of your theoretical 11-point scale (1–10, plus 9 Kick Ass) for reviewing products. Out of curiosity, I counted the 2017 occurrences of each rating, and found the following (rating/no. of occurrences): 1/0, 2/0, 3/0, 4/0, 5/0, 6/7, 7/34, 8/51, 9/30, 9KA/17, 10/0. Thus, you're using only a five-point rating scale. While I am sure it appeases potential advertisers to never get lower than a midscale rating, your readers would benefit from more differentiation.

–Scott Gaboury

ALAN DEXTER, EXECUTIVE EDITOR, RESPONDS: The key factor when it comes to our reviews is that we don't review just anything. We focus on hardware that is cutting-edge, exemplary, or just downright interesting. The exemplary stuff obviously gets high scores, and even most cutting-edge gear is pretty good these days, which leaves the catch-all of "interesting" to bring up the rear. The problem is, while some hardware is clearly better than others, the general quality level of hardware is incredibly high—it's been a while since we've seen a truly awful piece of kit. For example, take a look at the review of the Lenovo Explorer on page 76, it's not perfect by any means, but it does the job that it was designed to do well, and it makes several improvements over the Oculus Rift and HTC Vive.

Perfect Photos

I do lots of photo editing, and of real interest to me is monitor color. You frequently review monitors, but I've rarely seen mention of the colors the monitors show. It would be very useful if the reviews mentioned if the monitors provide adequate support for color correction. While some monitors allow color adjustment, there appears to be no way to make it to a verifiable standard. It would also be useful to know if the monitor's color could translate to a printer profile. Perhaps an article on how to adjust monitor color to some standard could be written.

–Jerry Straw

EXECUTIVE EDITOR ALAN DEXTER RESPONDS: While we don't necessarily mention color adjustments in every review, we do point out what the underlying screen tech is, and if a screen is lacking in its shipping color setup or ability to adjust it, we highlight this. We also point out if a more professional-focused screen supports a wider color gamut. That aside, you can adjust your printer and screen color profiles, although this has changed in the latest Windows 10 builds, so it's something we'll look at again shortly.

[NOW ONLINE]

AMD HIRES EX NVIDIA AND SYNAPTICS EXECS TO LEAD RADEON TECH GROUP

When AMD's former graphics boss Raja Koduri left the company to ultimately land at Intel, he left some pretty big shoes to fill. Too big for one person, apparently—AMD is bringing two leaders on board: Mike Rayfield and David Wang.

Rayfield will serve as senior vice president and general manager of AMD's Radeon Technologies Group, the company's dedicated graphics division, from which Koduri departed, and Wang will hold the role of senior vice president of engineering for the same department. Both will report to AMD CEO Dr. Lisa Su.

Read the full article at http://bit.ly/2rFIbO1.

↘ submit your questions to: comments@maximumpc.com

Built for Yesterday

I've seen that building old gaming PCs is becoming more popular (mainly Win 98 machines). Something like this would be interesting to see in an article/build. I'm also interested in doing this myself, but not sure what parts to look for.

–Ryan Holland

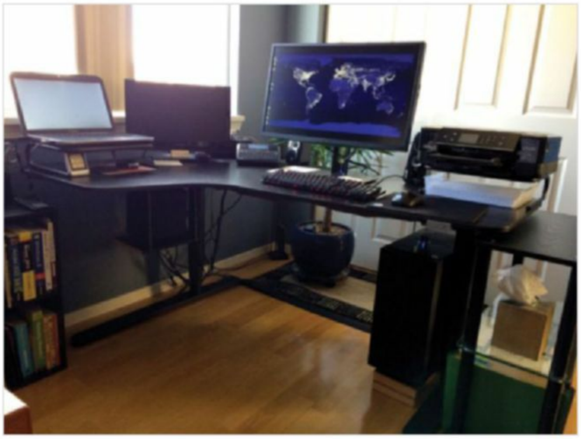
EXECUTIVE EDITOR ALAN DEXTER RESPONDS: This idea seems to be popping up more and more recently, so is something we'll look at in a future issue, possibly as a build. There is a problem piecing together such a system, though, and that is that you'll find yourself very much at the mercy of the seller of the hardware (unless you have an old machine in the attic or garage gathering dust). Sellers have cottoned on to the idea that there is interest in the market, sending prices skyward.

Be Warned

Great article on power supplies, but I suggest you add words of caution to those inclined to go looking. Modern power supplies—in most electronic devices—need PFC (power factor correction) circuitry. It uses voltage multiplication from the rectified A/C mains, so internal voltages are much higher. If one goes poking around with the A/C on, it may be the last thing one ever does. The company I work for makes most of our own power subsystems, up to around 24KW out, using water cooling. Keep up the great work! **–Will Collier**

EXECUTIVE EDITOR ALAN DEXTER RESPONDS: Fair point. We assumed no one would be silly enough to go poking around a power supply while it was plugged in, but you know what they say about assumptions. So remember, kids: Stay safe—make sure that the PSU is powered down before taking a peek inside.

[READER SPOTLIGHT]



A DIFFERENT KIND OF DESK

I recently read Zak's comments about building a table for his computer, where he mentioned IKEA. Not to discourage him from honing his carpentry skills, I offer the idea of buying a table from IKEA. I recently purchased a computer table from the company that has the added feature of being raised or lowered at the push of two buttons. The neat thing is that it allows for standing as well as sitting while using my computer. The only consideration is that cables need to have enough slack to allow for the topmost position without tipping things over. The cost is around $500. **–Peter Luptovic**

Safer Mode

Thanks for publishing my question and your answer in the recent issue; but your suggestion didn't work. I tried that seven times, powering down. The machine never came up far enough or went into "waiting" to get to any recovery choices. It does now if I force power off at just the right time (after the BIOS screen, when the circle of dots starts to spin).

But the recovery media created from the Fall Creators Update doesn't have a "safe mode" I could find. I did find that if I used the recovery media and "Advanced," and booted to a command prompt, I could use bcdedit ("bcdedit /set {default} safeboot minimal") to set the PC to boot into safe mode after being turned off. Once the problem is resolved, you get back to a normal boot using msconfig to turn off safe mode.

I also talked to Microsoft support via a callback. If they had come up with your answer, I would not have lost everything. Their response was to use the manufacturer's recovery media, which is impossible when you build your own PCs. Then they said I would have to install from scratch.

–Lee Boszak

EXECUTIVE EDITOR ALAN DEXTER RESPONDS: It's a pity you had to perform a complete system reinstall, especially if you weren't planning on doing so, but it sounds as though you've learned a lot in the process. The tip of using bcdedit to enable safe mode once again is worth passing on to other readers—hopefully, printing your experiences will mean that someone else doesn't have go through the same thing.

Integrated Graphics

This is in regard to the "Generation Game" article's multiple calls for Intel to remove integrated graphics from future i7/i5 CPUs.

There is an important aspect of integrated graphics that the author may not be aware of: Intel's Quick Sync Video. There are many software packages that make excellent use of these encoders/decoders. One example is Blue Iris's security camera software. I have seen a four-core CPU utilization completely pegged without Quick Sync, but enable QS, and utilization drops massively. The software is unusable without QS. There's a number of popular uses of Quick Sync, such as Handbrake transcoding and video streaming. There is also the complete lack of UHD Blu-ray playback from Nvidia. Intel's integrated graphics are simply required for certain HTPC duties.

Granted, the rest of integrated graphics is of no use to power gamers, but Quick Sync plus dedicated graphics is a very powerful combination for a multi-purpose PC.

For those who understand the value of Quick Sync, the article comes across as either ignorant or simply whining that more than six cores are not available for $400. If you want more cores, you have to pay for it. So, let's please stop with the calls to remove integrated graphics—just buy a higher spec CPU if you don't want it.

–Sam Chitwood

EXECUTIVE EDITOR ALAN DEXTER RESPONDS: We don't have a problem with the integrated graphics in the more entry-to-mainstream chips, it's more the fact that they're in chips where the integrated 3D graphics capabilities are never used. That's a waste of silicon that we are paying for. Having said that, you're right: There is plenty of goodness in Quick Sync, although getting it working alongside a discrete graphics card can be clunky.

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THE BUILDS

BUDGET

INGREDIENTS

PART		PRICE
Case	Phanteks Enthoo Evolv ITX	$70
PSU	EVGA 450 BT Bronze	$45
Mobo	ASRock AB350 Gaming-ITX/ac	$115
CPU	AMD Ryzen 3 1200	$110
GPU	EVGA GeForce GTX 1050 Ti 4GB SSC Gaming **NEW**	$220
RAM	8GB (2x 4GB) G.Skill Value 2400 **NEW**	$87
SSD	120GB HP M700 2.5-inch SSD	$48
HDD	1TB WD Blue 1TB 5,400rpm	$47
OS	Ubuntu Desktop Linux 16.04 LTS 64-bit	$16

Approximate Price: $758

THE CHEAPEST GEFORCE GTX 1050 TI right now costs a staggering $220. That's $50 more than it was last month, and indeed $80 more than it was at launch. In fact, it's $20 more than the launch price of the GeForce GTX 1060 3GB, which is significantly more powerful. We live in very strange times indeed. Cryptocurrency mining is still the driving force here, and while there are schemes in place to try to sort this out, at the moment, we are left with overpriced cards and systems that cost considerably more than they should. In many respects, it simply isn't a good time to build a budget system—in fact, a console may even be a better bet in the short term. There aren't many changes to our budget build elsewhere, other than a drop in memory speed to DDR4-2400 in an attempt to claw back some cash, which isn't exactly ideal, but we're eager to keep the overall system price as low as possible.

MID-RANGE

INGREDIENTS

PART		PRICE
Case	NZXT S340 Elite	$90
PSU	550W Corsair RM550X	$100
Mobo	MSI Z370 Tomahawk	$140
CPU	Intel Core i5-8400	$194
Cooler	Be Quiet! Dark Rock 3	$75
GPU	PNY GeForce GTX 1060 6GB **NEW**	$600
RAM	16GB (2x 8GB) ADATA XPG Gammix D10 2666	$178
SSD	256GB Samsung SM961 M.2 PCIe SSD	$146
HDD	Western Digital Blue Series 1TB 7,200rpm	$49
OS	Windows 10 Home 64-bit OEM	$100

Approximate Price: $1,672

THE FINANCIAL BEATING that the budget system takes this month is nothing compared to the battering that the mid-range build has endured. It doesn't start particularly well, with $10 increases on the PSU, motherboard, and case. Once again, though, it's the graphics card that floors us—the GeForce GTX 1070 we used last issue would set you back another $400 this month. That's $900 for a mid-range card. This left us with no other option but to shift our sights lower to settle on a GeForce GTX 1060 6GB. Hardly a card that will enjoy pumping out visuals to a 1440p screen, but given that the alternative is a $2,000 machine, our arm is being forced here. At least the memory and SSD haven't shifted, which is some good news. In fact, we saw a $6 saving on the CPU, which is welcome, but hardly offsets the horrors elsewhere. This isn't a great time to be building a mid-range PC system either, then, and there's no obvious end in sight.

TURBO

THE GRAPHICS CARD MADNESS that can be found afflicting the other two systems has extended to the high end as well, with the $750 card from last issue seeing its price bumped up to $1,199. That's not easy to swallow, but there's a distinct lack of better options out there—the non-Ti cards are currently the same price, while the 1070 is such a significant step down in performance that we can't justify it for our high-end build.

There's actually some good news on the pricing front for this machine, and it's due to the fact that AMD has announced Zen+ is on the way, sweetening the deal by shaving a substantial $120 off the asking price of the 1920X. We also saw a price drop on the memory front, albeit only a saving of $35, but we'll take anything we can get at this point. It's still a lot of money for 32GB of RAM, but maybe this is the start of a downward trend. We managed to pick up a $20 saving on the SSD as well, which all helps. There was no real change on the pricing of the Western Digital hard drive, although we did notice that you can grab a copy of *Far Cry Primal* with your purchase, which is worth picking up if you haven't had chance to flex your Neanderthal muscles lately.

Overall, these savings don't make much of a dent on the increase from the graphics card, which sees the final price hit an astounding $3,472, which is $271 more than it cost last issue for the same hardware. It is an incredibly powerful machine, though, that is as happy doing heavy lifting as it is rendering beautiful worlds to run around in.

For more of our component recommendations, visit www.maximumpc.com/best-of-the-best

INGREDIENTS

PART		PRICE
Case	Phanteks Eclipse P400S Tempered Glass Silent Edition	$90
PSU	Corsair RM750X Modular Gold	$110
Mobo	Asus Prime X399-A	$350
CPU	AMD Ryzen Threadripper 1920X	$680
Cooler	Noctua NH-U14S TR4-SP3 140mm	$80
GPU	MSI GeForce GTX 1080 Ti ARMOR 11G OC	$1,199
RAM	32GB (4x 8GB) G.Skill Ripjaws V Series DDR4 3200	$371
SSD	512GB Samsung 960 Pro M.2 NVMe	$308
HDD	4TB WD Black 7,200rpm	$184
OS	Windows 10 Home 64-bit OEM	$100

Approximate Price: $3,472

UPGRADE OF THE MONTH

MICROSOFT XBOX ONE X

This isn't an easy thing to say, and it isn't a recommendation we make lightly, but the graphics card market is so utterly screwed right now that we can't see what else to sensibly suggest. The simple fact is, if you're currently looking to build a machine mainly for gaming, the math simply doesn't add up. Instead, we suggest that you grab an Xbox One X, and enjoy that for what it is until things calm down. Just to put the pricing in perspective, this whole console will cost you less than a GeForce GTX 1060 6GB graphics card. It's a 4K Blu-ray player, competent media center, and has a growing games catalog as well. It's obviously not a real PC, and you are ultimately limited in what you can do with it, but as a stopgap, there's a lot worse that you could spend your money on.

$500, www.microsoft.com

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